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VOLUME I - TEXT

SUMMARY AND ANALYSIS OF RESULTS

**FIELD TREATABILITY STUDY
PHASE II**

**South Walnut Creek Basin
Surface Water Interim Measure/Interim Remedial Action**

OPERABLE UNIT NO. 2

**U. S. Department of Energy
Rocky Flats Plant
Golden, Colorado**

ENVIRONMENTAL RESTORATION PROGRAM

July 1993

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used in the Phase II Field Treatability Unit Study Report:

ARAR	Applicable or Relevant and Appropriate Requirement
AS	Analytical Sample
CDH	Colorado Department of Health
CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CUR	Carbon Use Rate
DCE	Dichloroethene
DCN	Document Change Notice
DL	Detection Limit
DOE	Department of Energy
DQO	Data Quality Objective
EBCT	Empty Bed Contact Time
EPA	Environmental Protection Agency
IM/IRA	Interim Measures/Interim Remedial Action
IM/IRAP	Interim Measures/Interim Remedial Action Plan
FSP	Field Sampling Plan
FS	Feasibility Study
FTU	Field Treatability Unit
GAC	Granular Activated Carbon
GPM	Gallons (U.S.) per minute, also gpm
GRRASP	General Radiochemistry and Routine Analytical Services Protocol

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HDPE	High Density Polyethylene
HI	Hazard Index
IDL	Instrument Detection Limit
LECR-I	Lifetime Excess Cancer Risk - Incidence
LECR-M	Lifetime Excess Cancer Risk - Mortality
mg/l	Milligrams per liter
O & M	Operations and Maintenance Manual
OU2	Operable Unit No. 2
PA	Protected Area
PAC	Powdered Activated Carbon
PCBs	polychlorinated biphenyls
PLC	Programmable Logic Controller
PPE	Personal Protection Equipment
pCi/g	Picocuries per gram
pCi/l	Picocuries per liter
QAA	Quality Assurance Addendum
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RFEDS	Rocky Flats Environmental Database
RFP	Rocky Flats Plant
RI	Remedial Investigation
RRS	Radionuclides Removal System
SS	Suspended Solids
SW	Surface Water
SOP	Standard Operating Procedure
SVOC	Semi-volatile organic compounds
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TK	Tank
TSD	Treatment, Storage or Disposal Facility
µg/l	Micrograms per liter
TOC	Total Organic Carbon
VOC	Volatile Organic Compounds
WQCC	Water Quality Control Commission

EXECUTIVE SUMMARY

This document presents the findings of the Phase II Field Treatability Unit (FTU) Study for the OU2 Surface Water Interim Measure/Interim Remedial Action (IM/IRA) at the Rocky Flats Plant. The scope of the OU2 FTU Program (including Phase I and Phase II) was submitted in the OU2 Surface Water Interim Measure/Interim Remedial Action Plan (IM/IRAP, DOE, 1991) which was subsequently approved for implementation by the U.S. Environmental Protection Agency (EPA) in March 1991 and the Colorado Department of Health (CDH) in May 1991. Phase I of the FTU study was initiated in May, 1991 and involved the use of bag filtration for suspended solids removal and granular activated carbon (GAC) for removal of volatile organic compounds (VOCs). Phase II of the FTU study commenced in April, 1992 with the objective of evaluating the effectiveness of expanded treatment for radionuclide and metals removal. The results of the Phase I study were presented in the Final Phase I Report, prepared in May 1992 (DOE, 1992). The results of the Phase II study are presented in this document.

The following objectives for the Phase II study were identified in the IRAP (DOE, 1991):

- Evaluate the potential of the treatment system to attain Applicable or Relevant and Appropriate Requirements (ARARs) for radionuclides, metals, and VOCs.
- Characterize influent surface water to facilitate recommendations for collection and treatment.
- Provide for the collection and treatment of flows exclusive of those resulting from high precipitation events.
- Characterize wastes and implement proper disposal in accordance with requirements.
- Initiate optimization of FTU operations to minimize chemical consumption and waste generation.

To supplement the IM/IRAP, an ARAR analysis and risk assessment was performed to support an analysis of options for future surface water management.

An evaluation of the effectiveness and cost of the FTU operations revealed that the treatment system was generally effective in reducing influent contaminant concentrations, although the cost of these reductions was exorbitant. Although influent concentrations were often below ARARs, comparison to effluent concentrations showed a small but measurable net reduction in concentration. Influent concentrations were generally too low to evaluate the system's effectiveness in treating higher contaminant levels; however, for those analytes that exceeded ARARs, the system was effective in reducing them to levels below ARAR. The cost of treatment of all three sources (excluding residual waste management) during Phase II was approximately \$29,000/pound of total metals removed, \$2,700,000/pound of total radionuclides removed, and \$557,000/pound of VOCs removed.

Residual waste management costs further offset any benefits realized by the operation of the FTU. Residual waste quantities have been significant and include not only sludge and spent GAC, but also air emissions from the diesel generator used to power the FTU, and solid and hazardous wastes generated during operation and maintenance of the system. The costs for treatment and disposal of sludge and GAC is estimated at \$130,000; additional costs will be realized for the storage, transportation and disposal of other solid and hazardous wastes.

The surface water characterization indicated that while one source (SW-59, a seep on the south bank of the South Walnut Creek drainage) contains analytes in concentrations that exceed ARARs, the surface water at two additional sources collected for treatment (SW-61 and SW-132) exhibit limited contamination. A risk assessment performed to evaluate the public health risks associated with direct ingestion of the three surface water sources concluded that the risks were well below EPA site remediation goals.

Considering the minimal public health risks associated with direct ingestion of untreated water from SW-61 and SW-132, the low frequency and magnitude of ARAR exceedances, the high

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cost of treatment, and the costs and risks of residual waste management, it is recommended that collection and treatment of surface water points SW-61 and SW-132 be discontinued. Furthermore, collection and treatment of SW-59 provides minimal risk reduction to public health. VOCs at this source represent the contaminant class posing the greatest public health risks. However, significant VOC losses to the atmosphere occur in the FTU prior to treatment by GAC. Such losses are occurring naturally without treatment. In light of this observation, continued operation of the IM/IRA should be re-evaluated. If the IM/IRA is discontinued, the treatment system could still be used to treat groundwater or surface water from OU2 or other OUs.

SECTION 1 INTRODUCTION

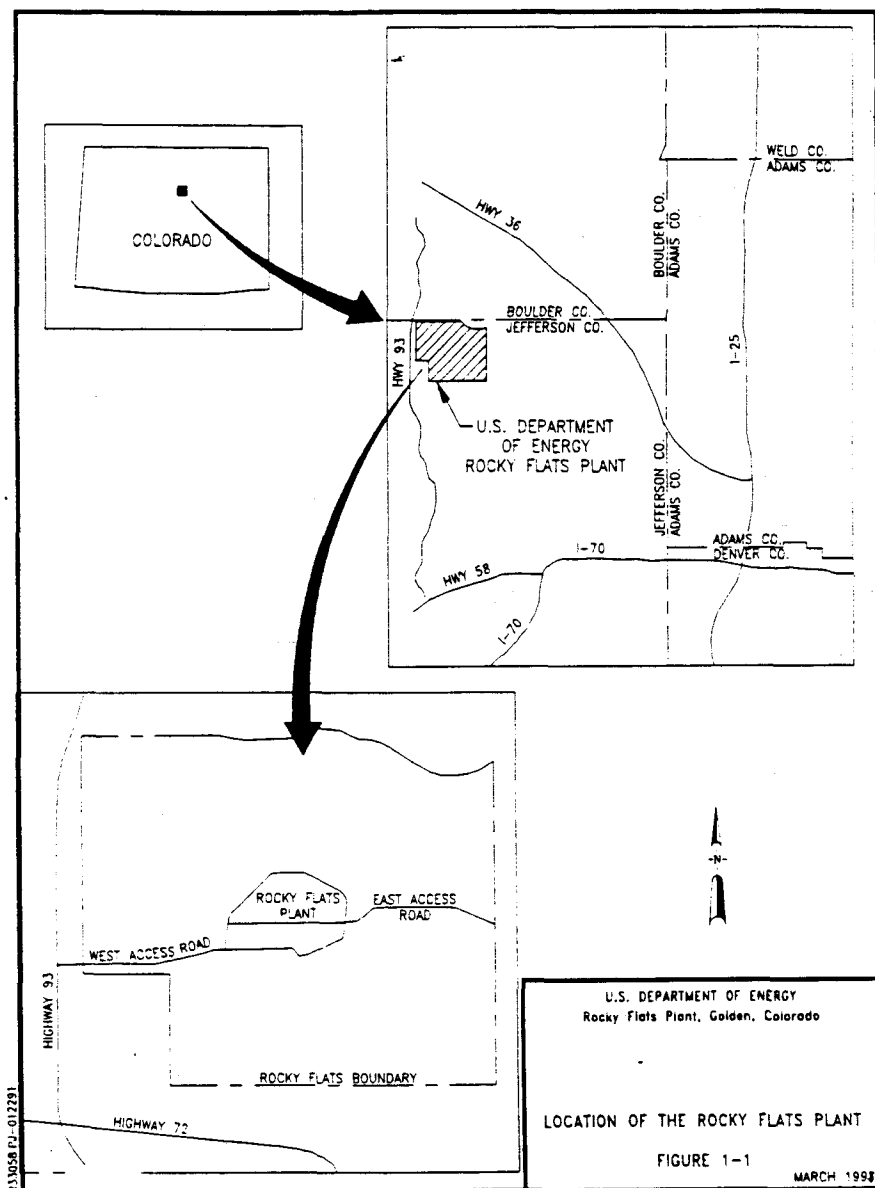
This document presents the findings of Phase II of the Field Treatability Unit (FTU) Study for the Operable Unit No. 2 (OU2) Surface Water Interim Measure/Interim Remedial Action (IM/IRA) at the Rocky Flats Plant. The scope of the OU2 FTU Program (including Phase I and Phase II) was submitted in the OU2 Surface Water Interim Measure/Interim Remedial Action Plan (IM/IRAP, DOE, 1991) which was subsequently approved for implementation by the U.S. Environmental Protection Agency (EPA) in March 1991 and the Colorado Department of Health (CDH) in May 1991. Phase I of the FTU study was initiated in May, 1991 and involved the use of bag filtration for suspended solids removal and granular activated carbon (GAC) for removal of volatile organic compounds (VOCs). Phase II of the FTU study commenced in April, 1992 with the objective of evaluating the effectiveness of expanded treatment for radionuclide and metals removal. The results of the Phase I study were presented in the Final Phase I Report, prepared in May 1992 (DOE, 1992). The results of the Phase II study are presented in this document.

1.1 OU2 SURFACE WATER INTERIM MEASURE/INTERIM REMEDIAL ACTION

Rocky Flats Plant (RFP) (Figure 1-1) began operations in 1951. Waste management practices at the RFP have resulted in environmental contamination at several plant site areas. One such area, designated as OU2 (Figure 1-2) includes the 903 Pad, Mound, and East Trenches Areas. Past waste management practices at OU2 included solid and liquid waste disposal, reactive metals destruction, and waste burning.

The remedial investigation (RI) for OU2 began in March 1987. The investigation included soil, groundwater, and surface water sampling and analysis. The RI identified the presence of VOCs, radionuclides, and metals in OU2 soils, groundwater and surface water. While investigations

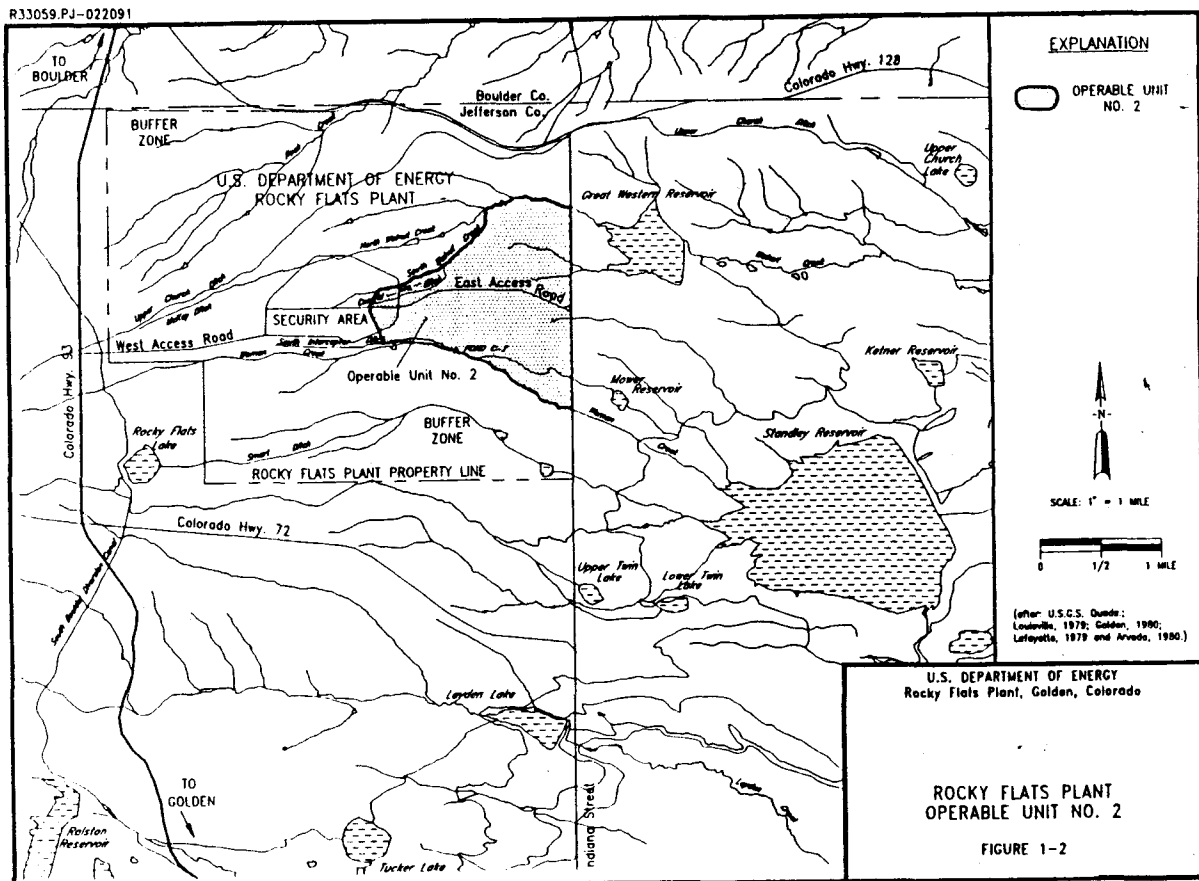
Figure 1-1
Location of the Rocky Flats Plant



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Figure 1-2
Rocky Flats Plant - Operable Unit No. 2



to fully characterize OU2 contamination continue and a final remedy is being determined, the Department of Energy (DOE) has pursued an OU2 surface water remediation under an IM/IRA.

The IM/IRAP Plan (IRAP), a field treatability unit study, was approved for implementation by the U.S. Environmental Protection Agency (EPA) in March 1991 and the Colorado Department of Health (CDH) in May 1991. The IRAP (DOE, 1991) identified specific methods of collection and treatment of contaminated surface water in a portion of the South Walnut Creek drainage at OU2. Contaminants originate from contaminated surface water in the Protected Area (PA) and south of the PA. Initial characterization of these waters indicates the presence of radionuclides, heavy metals, VOCs, and suspended solids to which contamination may be adsorbed. The IRAP identified specific analytes of concern and established possible chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) as effluent standards for discharge of the treated water. Influent concentrations (estimated from a flow-weighted maximum concentration model, and prepared to establish a basis for conceptual design for the surface water treatment system) and associated ARARs are presented in Table 1-1.

1.2 SITE LOCATION

As part of the IM/IRAP, surface water is collected from three locations within the drainage (Figure 1-3): SW-59, SW-61, and SW-132. SW-59 is a seep on the south bank of the South Walnut Creek drainage. SW-61 is located within South Walnut Creek and receives surface water runoff south of the PA (discharge from a corrugated metal culvert) and surface water runoff from within the PA (discharge from a concrete culvert). SW-132 is the discharge from a second corrugated metal culvert approximately 225 feet downstream of SW-61. The SW-132 discharge originates from South Walnut Creek west of Building 991 (a portion of South Walnut Creek that was filled during construction of Building 991).

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Table 1-1

Surface Water Contaminants
Identified in the South Walnut Creek Basin IM/IRAP^{1,2}

<u>Analyte</u>	<u>Unit</u>	<u>Average Concentration</u>	<u>ARAR</u>
Radionuclides			
Am-241	pCi/ℓ	0.53	0.05
Gross α	pCi/ℓ	730.00	11.00
Gross β	pCi/ℓ	545.00	19.00
Pu-239/240	pCi/ℓ	3.28	0.05
U-total	pCi/ℓ	11.69	10.00
VOCs³			
1,1-Dichloroethene	μg/ℓ	142	7.00
Carbon Tetrachloride	μg/ℓ	219	5.00
Chloroform	μg/ℓ	82	1.00
Tetrachloroethene	μg/ℓ	279	1.00
Trichloroethene	μg/ℓ	153	5.00
Vinyl Chloride	μg/ℓ	—	2.00
Metals-Dissolved			
Iron	μg/ℓ	—	300.00
Manganese	μg/ℓ	0.5790	50.00
Metals-Total			
Aluminum	μg/ℓ	25.1214	200.00
Arsenic	μg/ℓ	—	50.00
Barium	μg/ℓ	1.8530	1,000.00
Beryllium	μg/ℓ	0.0519	100.00
Cadmium	μg/ℓ	0.0132	5.00
Chromium	μg/ℓ	0.1918	10.00
Copper	μg/ℓ	0.2664	25.00
Iron	μg/ℓ	183.9643	1,000.00
Lead	μg/ℓ	0.1954	5.00
Manganese	μg/ℓ	3.3068	1,000.00
Mercury	μg/ℓ	0.0022	0.20
Nickel	μg/ℓ	0.2239	40.00
Selenium	μg/ℓ	0.0070	10.00
Zinc	μg/ℓ	1.3475	50.00

¹ From the IM/IRAP (DOE, 1991).

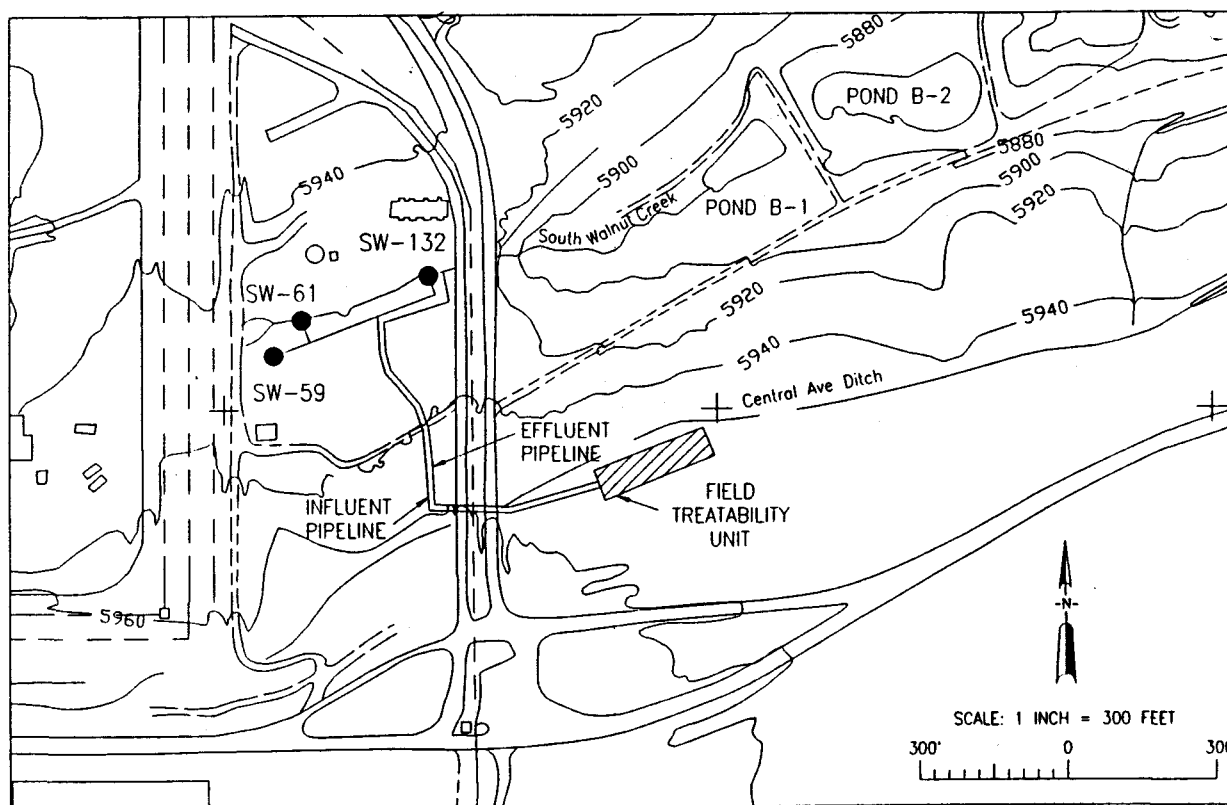
² Only analytes with ARARs are presented.

³ Analyzed by EPA Method 524.2.

— Not calculated in the IM/IRAP.

Figure 1-3
Field Treatability Unit Plot Plan
South Walnut Creek Basin

R37068.MBCW-031192/300



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Golden, Colorado

FIELD TREATABILITY UNIT PLOT PLAN
SOUTH WALNUT CREEK BASIN

FIGURE
1-3

1.3 HISTORY OF THE TREATABILITY STUDY

The FTU Study was implemented in two phases. The Phase I treatment system was initiated on May 13, 1991, began with the operation of the surface water collection system, equalization tank, bag filtration for suspended solids removal, and GAC treatment of VOCs. During Phase I, surface water collected from SW-59 and SW-61. Operation of the Phase I system continued until April 27, 1992, and was concluded with the Final Phase I report, Summary and Analysis of Results, which was prepared in May 1992 (DOE, 1992). The Phase I Report assessed performance of the system and its components, treatment system design, operational modifications, and waste stream characterization. The report also provided influent surface water characterization.

Operation of the Phase II program was initiated April 27, 1992 and presently continues through this date. The program incorporated the Radionuclides Removal System (RRS), involving chemical precipitation and membrane filtration for radionuclide and metals removal as treatment upstream of the GAC units. The bag filters were removed from the system as they were no longer required. Phase II also included collection of surface water from SW-132.

1.3.1 Phase I Field Treatability Unit (FTU) Program

The Phase I Treatment System treated 7.3 million gallons of water. A Final Report, Summary and Analysis of Results, was issued June 1, 1992 (DOE, 1992). Characterization of influent surface water for VOCs indicated that contamination of surface water was actually lower than that estimated in the IRAP. The most frequently occurring VOC, 1,2-dichloroethene (an analyte without an associated ARAR), was reported at concentrations averaging approximately 14 micrograms per liter ($\mu\text{g}/\ell$). Other VOCs were reported at detection levels of 5 $\mu\text{g}/\ell$ each; these included tetrachloroethene, trichloroethene, and carbon tetrachloride.

The GAC system proved effective and highly reliable in removing VOCs. Design of the unit, using lead and polish columns, proved effective in preventing breakthrough and discharge of

contamination. Improvement was needed in the use of upstream filters and back-washing techniques to minimize the carbon usage rate. During Phase I, GAC changeout was performed at approximately 120 day intervals, a calculated time based on contaminant concentrations.

Although the GAC system was not designed to treat radionuclides or metals, characterization of GAC influent and effluent for these contaminants was performed. The limited data analyzed from radionuclide and metals sampling showed effluent values that were generally below ARARs indicating the GAC system provided some removal for radionuclides and metals.

1.3.2 Sitewide Surface Water Sampling Program

The Sitewide Surface Water sampling program at RFP includes the IM/IRAP surface water stations at OU2. Measurements are made of various water quality parameters, as well as OU2 potential contaminants. These data were reported in the Phase I report and include data from January 1, 1990, through August 7, 1991. The implementation on January 1, 1990, of the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1991e) reflected imposition of uniform and high quality standards and procedures on analytical contractors. August 7, 1991, reflected the cut-off date for Phase I report data.

1.4 TREATABILITY STUDY OBJECTIVES

The objectives of this treatability study are summarized from the IRAP (DOE, 1991), the Project Work Plan and project meetings between DOE and EG&G. The objectives include the following:

- Evaluate the potential of the treatment system to attain ARARs for radionuclides, metals, and VOCs.
- Characterize influent surface water to facilitate recommendations for collection and treatment.

- Provide for the collection and treatment of flows exclusive of those resulting from high precipitation events.
- Characterize wastes and implement proper disposal in accordance with requirements.
- Initiate optimization of FTU operations to minimize chemical consumption and waste generation.

To supplement the IM/IRAP, an ARAR analysis and risk assessment was performed to support an analysis of options for future surface water management, specifically the necessity of continued collection of some of the surface waters. The results of this analysis are presented in this report in Section 5.0.

SECTION 2

TREATMENT SYSTEM DESCRIPTION

A process flow diagram showing the Phase II treatment system is presented in Figure 2-1. This equipment is housed in three trailers designated GAC, RRS I, and RRS II. As-built drawings of the system have been prepared and are available.

2.1 TREATMENT PROCESSES

2.1.1 Surface Water Collection, Transfer, and Equalization

The Treatment Unit is designed to divert and transfer surface water flows from SW-59, SW-61, and SW-132. The maximum design flow rate is 60 gallons per minute (gpm). Flow in excess of the design capacity is permitted to overflow the collection system and continue downstream along the pre-IM/IRAP flow path.

Each collection system includes a precast reinforced concrete catch basin with a stainless steel submersible pump. Each pump is located inside a catch basin, and its operation is controlled by a float switch. Flow from SW-132 is pumped to the catch basin at SW-61. Flow from SW-59 is joined with the combined flow of SW-61 and SW-132 for transfer to the FTU. Raw water is pumped from the catch basins to a flow equalization tank. Flow rate monitoring at all collection points was in place by August 18, 1992.

Transfer piping consists of approximately 1,200 feet of 2-inch, inside diameter (i.d.) high-density polyethylene (HDPE) located concentrically inside containment piping. Containment piping is heat traced, insulated, and monitored for leakage. Return flow is provided by 3-inch piping, which is also heat traced and insulated, but not contained because the water is treated.

Collected flow is discharged into a 10,000-gallon equalization tank fabricated of cross-linked polyethylene which is provided with secondary containment and located adjacent to the treatment trailers. This tank provides hydraulic surge capacity and smooths variations in contaminant concentration. Surface water influent levels in the tank are continuously monitored and displayed. Level indication includes low, high, and overflow visual and audible alarms at 5, 90 and 95 percent of tank capacity. At peak flow (60 gpm) the tank can provide nearly 3 hours of equalization time. Equalization tank effluent flow rates are maintained by a valve at approximately 50 gpm. This is to provide a consistent flow rate through the treatment system.

2.1.2 Radionuclides Removal System

Water from the Equalization Tank is pumped into Reaction Tank No. 1 (TK-1), a continuously stirred, stainless steel tank. In this first 1,200-gallon tank, sulfuric acid is added to lower the pH to approximately 4.5. This step shifts the carbonate equilibrium from carbonate to bicarbonate, minimizing formation of uranium carbonate complexes which would resist chemical precipitation. Acidification also neutralizes total alkalinity. Ferric sulfate is then added as a coagulant and a coprecipitating agent.

Process water then overflows to Reaction Tank No. 2 (TK-2), a 1,200 gallon continuously stirred, stainless steel tank. Lime slurry is added to TK-2 to raise the pH above 9.5 (under normal operating conditions). This causes precipitation of metals as metal hydroxides. Radionuclides and metals adsorb to the particulates and are entrained in the flocs.

Under sustained high flow and/or high turbidity conditions, pH is elevated to approximately 10.5 by increased addition of lime slurry. The additional lime slurry increases the solids level which aids the next treatment step. The increased solids concentration increases the scouring action in the membrane circuit, and helps to maintain an effective filtration rate under these conditions. The amount of ferric sulfate (commercial Ferrifloc™) added to TK-1 also varies. This treatment occurs in RRS I which also houses the equipment for preparation, storage, and transfer of the chemical treatment agents to the reaction vessels.

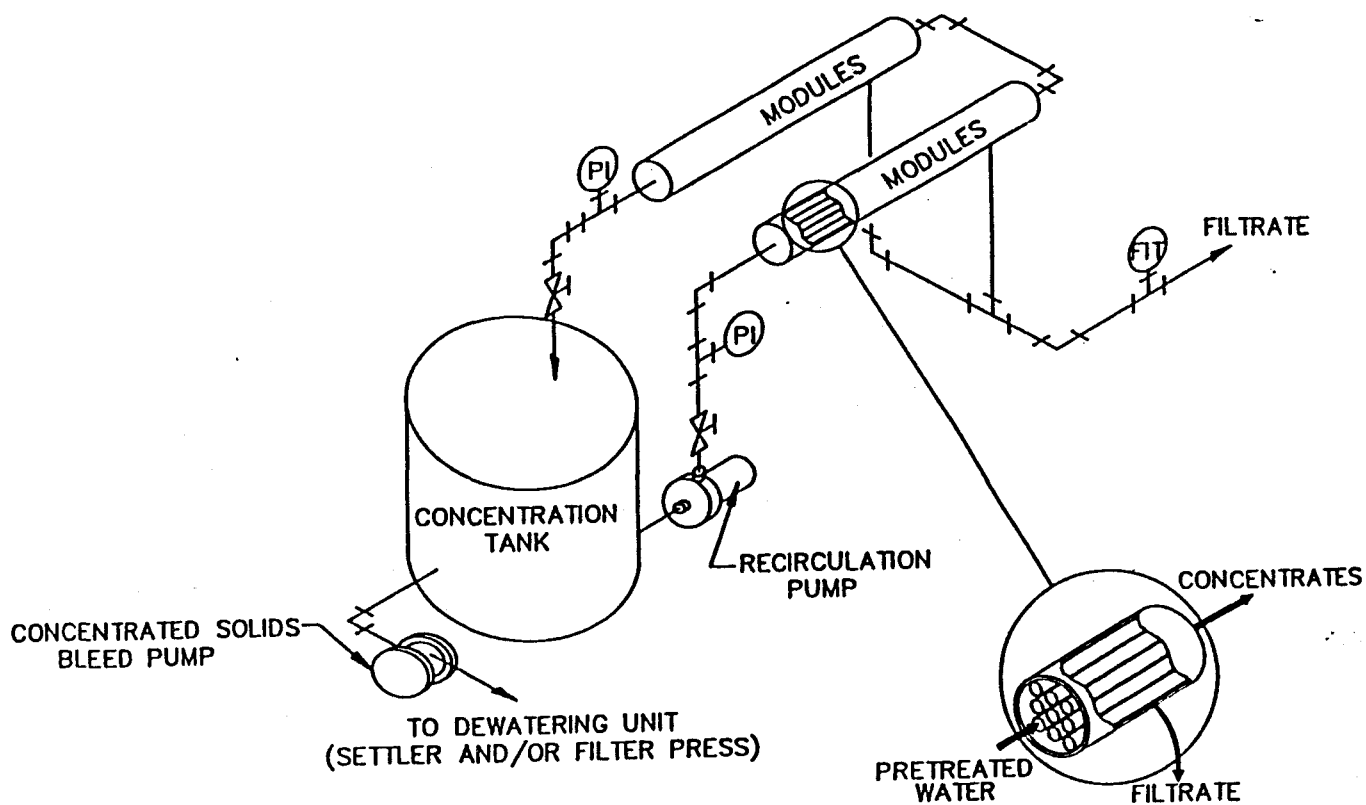
The slurry of precipitated, co-precipitated and flocculated solids overflows from TK-2 into the solids concentration tank, TK-8. Residence time is not a controlled parameter in TK-2. TK-8 has a capacity of 3,000 gallons, is constructed of fiberglass-reinforced plastic, and is equipped with baffles, level controls, and a recirculation pump. Solids concentration in TK-8 is estimated twice daily by use of a pre-calibrated sample bottle. The sample bottle was calibrated by analytical laboratory determination of solids in previous samples. The analytical values of solids are used as a standard to compare observed sedimentation levels with actual solids values. Slurry that accumulates in TK-8 is circulated through the filtration system. The concentration and microfiltration systems physically separate the flocs formed in TK-2.

The filtration system is a shell and tube configuration consisting of 27 modules configured into three parallel paths with the membrane on the inside of the tubes. Figure 2-2 presents a diagram of the filter arrangement and detail of the filter. The permeate passes through the tubes perpendicular to the main flow at a relatively low operating pressure. The design is cross-flow so that high velocity flows clean the filter by scouring action. The filtration membrane is polymeric and rated at 0.10 micron (nominal) pore size by the manufacturer.

The permeate flows radially through the tubular membrane into a concentric annular space. Manifolds are provided to collect the filtrate and direct it by gravity flow to a neutralization tank. In the neutralization tank, TK-11, the permeate is neutralized to pH 7.0 by adding sulfuric acid. The neutralized liquid then flows to the GAC treatment units in the GAC trailer.

Filtered solids, which remain inside the filter membrane tube, are returned to the concentration tank. To maintain an effective filtration rate, solids concentration in TK-8 is controlled at a level of approximately 5 to 10 percent. Solids concentration is controlled by maintaining the liquid level in the concentration tank, sludge drawdown (sludge wasting), lime addition in TK-2, and the addition of powdered-activated carbon (PAC) to TK-8, when an increase in solids is needed to bring the level to the desired range.

Figure 2-2
Field Treatability Unit
Filtration Unit Basic Components



When solids in TK-8 have accumulated to the desired range, the sludge is drawn off for sludge storage and dewatering, which is performed in RRS I. Sludge is drawn off the bottom of the concentration tank and transferred to a conical bottom holding tank, TK-12. Settling is allowed to take place for approximately 12 hours. During periods of sludge accumulation, supernatant liquid is returned to the concentration tank by overflow. When sufficient solids have accumulated, they are pumped via an air operated slurry pump to the adjacent plate and frame filter press, where dewatering occurs.

The filter cake produced by the plate and frame filter press contains approximately 50 percent solids. The filter press accepts the pumped slurry until the 100 pounds per square inch (psi) pump discharge pressure is counterbalanced by filter cake resistance. At this point, filtrate flow back to TK-8 can no longer take place and flow terminates. The filter is allowed to drain and residual pressure returns drainage to TK-8. The press is opened and sludge drops into the storage drums beneath.

2.1.3 GAC Treatment

Neutralized process water is pumped from TK-11 in RRS II to the GAC treatment units. The GAC treatment units are housed in a separate GAC trailer. The GAC trailer contains four Cyclesorb™ units that are plumbed together using stainless steel quick connect couplings. Two units are on line, and two units are on standby. Standby units are prepared for use by soaking with treated water and are kept in the ready and warm condition. During Phase I, the bag filters were housed in the GAC trailer. These bag filters have been replaced by the RRS and have been eliminated from the treatment process.

Characterization data from the RI were used by the process supplier (Calgon Corporation) to recommend a suitable carbon. A proprietary A-300 carbon derived from coconut was selected

for this application. Alternative carbons were not evaluated in this program. The GAC units used in Phase I were changed to fresh units in Phase II.

The GAC system consists of two Cyclesorb™ units arranged in series. Each unit is a stainless steel column measuring 60 inches in diameter, 87 inches in height, and contains 2,000 pounds of A-300 carbon. The units are sequenced in a lead/polish mode based on a timed interval that is determined by flow and concentration of organics. Empty bed contact time (EBCT) was specified by the IM/IRAP as approximately 18 minutes using a conventional downflow, sequential, lead/polish GAC treatment sequence. The design flow rate of 60 gpm provides a residence time of approximately 20 minutes. Effluent flow rates are monitored and flow returns to South Walnut Creek by pipeline.

2.2 SYSTEM OPERATION AND MAINTENANCE

2.2.1 Instrumentation and Controls

The collection system is automated and uses float controlled pumps. The RRS is a semi-automated system, depending primarily on pH controllers. The GAC system is controlled by the RRS discharge. The membrane cleaning cycle is controlled by a Programmable Logic Controller (PLC).

2.2.2 Electrical Supply

Electrical power to the FTU is provided by a mobile diesel generator unit rated at 250 kilowatt (kW), pending connection of plant power to the treatment unit.

2.2.3 Operational Chemicals

RRS: Sulfuric Acid, 50%
Lime, technical grade
Powdered Activated Carbon
Ferric Sulfate, technical grade
Hydrogen Peroxide, 50%

GAC: A-300 GAC

Generator: Diesel Fuel

2.2.4 Personnel Protective Equipment

Personnel Protective Equipment (PPE) is worn routinely when conducting sampling or making sludge. Equipment includes tyvek coveralls, nitrile gloves, and boots. A respirator is worn during sampling of spent activated carbon. A Health and Safety Plan is in effect for system operation and maintenance.

2.2.5 System Maintenance

2.2.5.1 Collection System

Collection system maintenance consists of pump cleaning to remove accumulated debris and periodic inspection of float mechanisms and pumps (particularly after high precipitation events).

2.2.5.2 Filtration System Cleaning

Filtration system cleaning is necessary due to the porous nature of the membrane and the turbid nature of the influent. Periodic flushing with cleaning chemicals returns the membrane to full capacity. This periodic cycle takes approximately two hours to complete and generates no waste external to the process. Backflushing and chemical cleaning using hydrogen peroxide which is

acidified with sulfuric acid are employed for this purpose. Two-300 gallon polyethylene tanks (TK-9 and TK-10) that hold the cleaning solutions are provided in the space beneath the filter.

The RRS is shut down during the cleaning cycle. Liquid level in the equalization tank rises during this period. For short periods, cleaning can be delayed by adding PAC to the concentration tank if solids in the tank are on the low side of the desired range. The increased scouring can temporarily maintain filtration and delay cleaning.

2.2.5.3 GAC Column Changeout

During GAC column changeout, the polishing column is moved to the lead position and a fresh column is moved to the polishing position. The columns are sized to handle at least 120 days of contaminated flow. Use of a fresh polishing column precludes discharge of contaminated water.

2.2.6 Waste Management

Process knowledge suggests that wastes be managed as low-level mixed waste pending characterization. Accordingly, management practices are implemented for requisite personnel training and supervision, waste storage, and documentation.

2.2.6.1 Personnel Training

Waste generator, inspector, and verifier training have been implemented for operating personnel in accordance with Procedures 1101, 1102 and 4034 (EG&G, 1992b; 1992c; 1992d). Waste verifiers are called to the OU2 site when the sludge press is emptied and packaging is performed.

2.2.6.2 Waste Storage Facilities

RCRA 90 Day Accumulation Area

A Resource Conservation and Recovery Act (RCRA) storage area (RCRA Unit EM1890) has been designated at the RFP and is permitted to receive drummed and labeled sludge from the RRS and spent GAC. Sludge is stored in double-lined, white, steel drums, and GAC is stored in process vessels. Appropriate forms accompany the containers until final disposal of the waste occurs.

Interim Storage Area

RCRA Unit 18.04 has been permitted to receive OU2 wastes from the 90-day area. Transportation is provided by closed truck, operated by RFP transportation personnel.

2.2.6.3 Documentation

Waste Residue Travellers (internal plant manifests) are prepared in accordance with requirements, and waste logs are maintained. Waste Stream Residue Identification and Characterization (WSRIC) documentation has been prepared (EG&G, 1993d).

SECTION 3

TREATABILITY STUDY PROCEDURES

The approach to implementing this Treatability Study is presented in the Phase II Work Plan (EG&G, 1993g). Detailed information is presented in the Phase II Field Sampling Plan (FSP) (EG&G, 1993f). Weekly and monthly samples are taken for analytes of concern including radionuclides, metals, and VOCs in accordance with the GRRASP (EG&G, 1991b), which specifies sample size, preservation and holding time. Sampling is performed in accordance with Standard Operating Procedures (SOPs) and SOP Addenda which have been prepared for process water and sludge samples.

3.1 SURFACE WATER SOURCES SAMPLING AND ANALYSIS

South Walnut Creek water is sampled routinely as part of the site-wide surface water monitoring program at SW-59, SW-61, and SW-132. Surface water was collected from SW-59 and SW-61 throughout Phase I and Phase II. Surface water was also collected from SW-132 upon implementation of the Phase II program. Measurement of combined influent flow rates has been conducted since implementation of Phase I.

Grab samples from the OU2 seep and stream locations have been taken monthly since 1990 under GRRASP as part of the site-wide monitoring program, and semi-monthly since August 1992 at the request of the OU2 Project Manager. These surface water samples are sent to a different off-site laboratory for analysis than the samples collected from the treatment unit. While the laboratories follow the same analytical protocols, some statistical variability is introduced in using multiple laboratories. Also, the surface water samples are not necessarily collected on the same dates as the treatment system influent samples. As a result, the data from the two programs are not directly comparable.

3.2 TREATMENT SYSTEM SAMPLING AND ANALYSIS

The sampling and analysis program allows for the measurement of process parameters at key points in the treatment process. The FTU sampling points are shown in Figure 2-1. The sampling locations, designated RS1 through RS9, are defined as follows:

- RS1 - Surface Water Collection Sumps
- RS2 - Equalization Tank Effluent
- RS3 - Reaction Tank No. 1 Effluent
- RS4 - Reaction Tank No. 2 Effluent
- RS5 - Neutralization Tank Effluent
- RS6 - Lead GAC Unit Effluent
- RS7 - Polishing GAC Unit Effluent (System Effluent)
- RS8 - Filter Press Solids Cake
- RS9 - Spent GAC (Lead Unit)

Sample points RS3 and RS4 were not sampled because a consistent effluent characterization was expected. Table 3-1 summarizes sample types, sample locations and sampling frequencies at RS1 through RS9.

3.2.1 Equalization

Sampling of the equalization tank water is conducted at the outlet and at point RS2. Analytes include radionuclides, metals, and VOCs. Sampling and analyses at points RS1 and RS2 allow monitoring of changes which may occur during collection, transport, and equalization. Sampling at RS2 allows characterization of water influent to the RRS. Composite samples are collected for metals and radionuclides at RS1; grab samples are collected for metals and radionuclides at RS2. The data are not directly comparable. Also, sampling events for RS1 are not synchronous with the sampling events for site-wide surface water sampling. Consequently, two independent sets of data are available for source water characterization.

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Table 3-1

Field Treatability Study
Phase II Sampling
and Analysis Plan

<u>Sample Type</u>	<u>Sample Locations</u>	<u>Sampling Frequency</u>
Aqueous Process Samples		
VOCs	RS2 RS1, RS5, RS6, RS7	No samples taken. One grab sample per week.
Dissolved Metals	RS2 RS5 RS1, RS7	One grab sample per month. One grab sample per week. One composite sample per week.
Total Metals	RS2 RS5 RS1, RS7	One grab sample per month. One grab sample per week. One composite sample per week.
Dissolved Radionuclides	RS2 RS5 RS1, RS7	One grab sample per month. One grab sample per week. One composite sample per week.
Total Radionuclides	RS2 RS5 RS1, RS7	One grab sample per month. One grab sample per week. One composite sample per week.
Solids Samples		
Filter Cake (for VOCs, metals, radionuclides)	RS8	One composite sample per every two drums.
Spent GAC (for VOCs, SVOCs, metals, radionuclides, pesticides, herbicides)	RS9	One composite sample taken every changeout (approximately every four months).

3.2.2 Radionuclides Removal System

Sampling is conducted at the inlet to and outlet from the RRS at points RS2 and RS5. Analytes include radionuclides, metals, and VOCs. Field parameters include turbidity and suspended solids.

3.2.3 GAC Treatment System

Sampling is conducted at the inlet to, outlet from, and in between the GAC units. Analytes include radionuclides, metals, and VOCs. Sample points are RS5 and RS6 and RS7. Analysis of VOCs was performed using EPA Methods 502.2 and 524.2.

3.2.4 Waste Stream Characterization

To manage wastes in accordance with RCRA and DOE requirements, waste streams are analyzed for hazardous and/or radioactive constituents. Characterization of waste products allows for assessment of disposal and regeneration options. Current waste management practices are based on process knowledge, pending full characterization of wastes.

3.2.4.1 Sludge

Sludge sampling is performed at RS8. Analysis includes Toxicity Characteristic Leaching Procedure (TCLP) for metals and VOCs, and acid digestion for radionuclides. A Paint Filter Test is used to determine effectiveness of dewatering.

3.2.4.2 Spent GAC

Spent GAC is analyzed by TCLP for metals and VOCs and by acid digestion for radionuclides. Additional characterization is done for herbicides and pesticides, semi-volatile organic compounds (SVOCs), and polychlorinated biphenyls (PCBs). The sample point is RS9.

3.3 QUALITY ASSURANCE/QUALITY CONTROL

3.3.1 Data Quality Objectives

The overall objective of the South Walnut Creek Surface Water IM/IRAP is the mitigation of downgradient contaminant migration within surface water by means of the collection and treatment of contaminated surface water to achieve, to the extent practicable, ARARS. The objective of the IM/IRAP Field Treatability Unit (FTU) system operation is to meet the treatment goals. The results of this FTU study are intended to permit evaluation of the treatment system's ability to meet treatment goals and to characterize residues to facilitate waste management. Data users include project personnel as well as EG&G and DOE management, CDH, EPA, and the general public. For this purpose, the Work Plan and the Quality Assurance Addendum specify EPA Level IV analysis (CLP or higher), rigorous quality assurance/quality control (QA/QC) and 100 percent validation.

3.3.2 QA/QC Program

FTU sampling and analysis activities are conducted in accordance with QA/QC guidance presented in the RFP Site-Wide Quality Assurance Project Plan (QAPjP) (EG&G, 1991a), QAPjP Quality Assurance Addendum (QAA) 2.3 (EG&G, 1991b) and QAPjP QAA 2.3(A) (EG&G, 1991c). QAA 2.3 and QAA 2.3(A) have been prepared to specifically address QA/QC requirements for construction, installation, and operation of the South Walnut Creek Basin FTU. All QA/QC guidelines are followed except the field QC procedures. The QA/QC guidance presented in these documents provides the framework for ensuring an acceptable quality of sampling and analyses during the field treatability study.

3.4 DATA MANAGEMENT

Data management is handled in accordance with protocols for field measurement, sample management, and analytical data management.

3.4.1 Field Logs

Field data recorded in logbooks include shift information, sampling event information, field data, sampling equipment calibration measurements, air sampling information, operations and maintenance (O&M) information, and waste material information.

3.4.2 Chains of Custody

Chains of custody are generated for all analytical samples. Off-site shipment of samples requires a Document Control Change Notice (DCN) to existing shipping procedures. The DCN authorizes the use of express carrier shipment, while preserving the chains of custody.

3.4.3 Rocky Flats Environmental Data System

Data is managed in accordance with the Rocky Flats Environmental Data System (RFEDs). The Data Cap subsystem provides the Sample Management Office with advice on samples, shipment, designated laboratories, and required analytes. The electronic disc deliverable permits sample tracking and facilitates laboratory contract management.

Analytical laboratory data is returned simultaneously both to RFEDs and to a data validation contractor. Samples are shipped to several off-site laboratories. Data released from RFEDs may not be totally validated. Approximately 50 percent of available analytical results presented here have been validated. Rather than delete nonvalidated data, this study has included all available data. These data are presented in Appendices C and E for surface water and process data, respectively. Data flagged with a "V" indicate validation has been completed. Where results appear questionable, the data have been re-examined either statistically or in relation to other parameters, to test useability. The cutoff date for analytical data contained in this report was March 1, 1993.

3.4.4 Statistical Analysis of Data

The surface water chemical characterization is based on data available from May 1991 to March 1993. Surface water data for SW-59, SW-61, and SW-132 exist for the time preceeding May 1991; however, collection and treatment of surface water began in May 1991. Prior to May 1991, SW-59 was allowed to run into SW-61. The intent of the surface water chemical characterization is to characterize the flows based on current conditions.

The risk assessment is based on a list of potential surface water contaminants generated using all available data. This includes data from 1990 to March 1993 (GRASSP specifications were not in place until 1991).

The surface water and process data summaries and graphs are based on those analytes which are presented in the IM/IRAP, Appendix E, as having ARARs. The list of potential contaminants used in the risk assessment include analytes that have ARARs and some which have the designation To Be Considered (TBC). The risk assessment will, therefore, be based on a more comprehensive list of potential contaminants.

SECTION 4

RESULTS AND DISCUSSION

4.1 DATA QUALITY

With few exceptions, data were collected in accordance with the QA/QC documents specified in Section 3.3.2. The QA/QC procedures assure the precision, accuracy, comparability, completeness, and representativeness of the data. The data presented in this report meet the data quality objectives for the treatability study program.

Analytical data were generated using EPA and other well-established methods identified in the QA/QC Plan. EPA CLP methods and protocols were used in the analysis of Target Compound List (TCL) volatile organics and Target Analyte List (TAL) metal parameters. Analytical methods for radionuclides (non-CLP analytes) are based on EPA and other published references. The analytical data were reviewed and validated independently of the laboratory, and the results were documented in data validation reports. EPA data validation functional guidelines were used for validating metals data for CLP analysis. Non-CLP analytical data were validated using data validation guidelines developed by the Environmental Restoration (ER) Program, because such guidelines have not been published by the EPA. These non-CLP guidelines are based on EPA validation functional guideline concepts and tailored to non-CLP analytical methods.

Three classes of data quality are used in the ER Program: (1) V - valid and usable without qualification; (2) A - acceptable for use with qualification(s); and (3) R - rejected (unacceptable).

Valid data meet the following objective standards, where applicable:

- 1.* analytical methods followed.
2. acceptance criteria achieved.
3. sufficient number and type of QC samples analyzed.
- 4.* QC limits achieved.

- 5.* compounds and analytes correctly identified.
- 6.* equipment/instrumentation calibration criteria achieved.
7. sample holding times met.

* primary validation criteria

Data that are acceptable with qualifications meet most of the above standards. At the minimum, all of the primary validation criteria are achieved within acceptable limits. Rejected data fail to meet primary validation criteria. As shown in Appendix C, analytical results are coded with the appropriate data qualifier (V, A, or R) based on the results of the data validation. For the purposes of this report, valid and acceptable data were considered of equal utility. Rejected data have not been used in any statistical computations or assessments. However, it should be noted that data that have not yet been validated were used in the statistical computations and assessments out of necessity, i.e., to provide an adequate quantity of data for characterization of the surface water sources and assessment of the performance of the treatment units. Use of unvalidated data should not reduce the soundness of the conclusions drawn, because most of the data that have been validated are designated as either valid or acceptable.

Table 4-1 summarizes the data validation status for the analytical data presented in this treatability study report. This table provides, by analyte group, the percentage of validated data and the percentage of rejected data for those data evaluated. Overall, greater than 50% of the data has been validated. With the exception of radiochemistry, less than 5% of the data in any individual analyte group has been rejected. The high percent rejection (15.2% and 56.1% for process and surface water data, respectively) of the radiochemistry data does somewhat compromise attaining the data quality objectives proposed for the study; however, such high rejection rates are not uncommon for low concentrations of radionuclides where the error term often exceeds the reported value.

The one aspect of the QA/QC program for the treatment system that was not implemented was the collection of field QC samples, i.e., trip blanks, field blanks, equipment rinsate blanks, and field duplicates. These QC data would allow assessment of the influence, if any, of the sampling

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Table 4-1

Summary of Data Validation

Analyte Group	Process Data (includes sludges, water, and carbon from Phase 2)	Surface Water Data (5/1/92-present)
Percent Validated		
Total Radiochemistry	44.6	68.5
Total Metals	59.8	74.3
Dissolved Metals	47.6	71.3
CLP Volatiles	100	67.3
EPA Method 524.2	12.8	0.0
Percent Rejected (Of Validated Results)		
Total Radiochemistry	15.2	56.1
Total Metals	1.0	1.0
Dissolved Metals	1.2	1.8
CLP Volatiles	3.0	1.0
EPA Method 524.2	0.0	Not applicable

equipment and procedures on the reported results. This includes assessing sample contamination arising from the sample bottle or determining the degree of cross-contamination of samples due to faulty decontamination procedures. The field duplicates would allow determination of the precision of the sampling technique. Although not collecting field QC samples limits data quality assessment as outlined above, the data do not suggest that sampling precision or laboratory/ cross-contamination is a problem, i.e., there are few outliers and data trends appear reasonable. However, it is noted that collection of field QC samples has now been implemented.

4.2 SURFACE WATER SOURCES CHARACTERIZATION

4.2.1 Surface Water Flow Rates

Total flow to the treatment system has been measured since May 1991 (refer to Section 4.3.1). The total flow at each station, the date, duration, and volume of surface water collected at each source were not obtained.

For the purposes of the risk assessment presented in Section 5 and Appendix B, it is assumed that the average annual flows at each source that are cited in the IRAP (DOE, 1991) are still applicable. They are as follows:

<u>Station</u>	<u>Flow (gpm)</u>
SW-59	1
SW-61	14
SW-132	<u>5</u>
Total	20

It is noted that, based on the total volume of surface water collected for treatment (refer to Section 4.3.1), the daily average flow of surface water collected since the treatability study was initiated in May 1991 is approximately 13.5 gpm. The flow contributed from SW-59 was approximately 7% during the time this flow was measured which equates to a SW-59 flow of

approximately 1 gpm. This value indicates that the flow cited in the IRAP for SW-59 is a reasonable estimate of the current flow. With the exception of the limited flow data collected for SW-59, flow rates have not been measured at the individual sources.

4.2.2 Determination of Potential Surface Water Contaminants

A statistical methodology for comparing background and site data has been used to determine if concentrations of analytes at SW-59, SW-61, and SW-132 are statistically significantly higher relative to background (Appendix A). Data for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), radionuclides, total metals, and dissolved metals were considered in this analysis. If the concentrations of analytes in OU2 surface water were found to be statistically higher than the background surface waters, the analytes were designated as potential contaminants at the surface water stations. The data presented in the Background Geochemical Characterization Report (EG&G, 1992) were used as the background reference for the statistical comparison to the OU2 data.

As shown in Table 4-2, there are many organics, metals, and radionuclides identified as potential contaminants in surface water at the sources. Based on chemical usage and the nature of the RFP historical mission, the presence of chlorinated solvents, plutonium, americium, and uranium on the list of potential contaminants is not surprising. In terms of waste origin, it is not understood why the metals are on the list of potential contaminants. Nevertheless, all potential contaminants are addressed in the risk assessment (Appendix B) and those with ARARs are addressed in Section 4.2.3.

4.2.3 Characterization of Surface Water Contamination

This section summarizes the results of contaminant characterization for the three surface water flows collected for treatment (Stations SW-59, SW-61, and SW-132). Each of the flows have been sampled and analyzed for EPA's TCL VOCs, radionuclides, total and dissolved EPA

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Table 4-2
Potential Contaminants at the Surface Water Sources

Station	Organic Analytes	Radionuclides	Metals (Total)	Metals (Dissolved)
SW-59	1,1,1-Trichloroethane	Americium - 241	Barium	Barium
	1,1-Dichloroethane	Plutonium - 239,240	Cadmium	Calcium
	1,1-Dichloroethene	Uranium, Total	Calcium	Magnesium
	1,2-Dichloroethane	Uranium - 233,234	Magnesium	Sodium
	1,2-Dichloroethene	Uranium - 235	Sodium	Strontium
	Acetone	Uranium - 238	Strontium	Zinc
	Carbon Tetrachloride		Thallium	
	Chloroform		Zinc	
	Methylene Chloride			
	Tetrachloroethene			
	Trichloroethene			
	Vinyl Chloride			
SW-61	1,1,1-Trichloroethane	Americium - 241	Barium	Barium
	1,1-Dichloroethene	Plutonium - 239,240	Cadmium	Lithium
	1,2-Dichloroethene	Uranium, Total	Calcium	Calcium
	Acetone	Uranium - 233,234	Magnesium	Magnesium
	Carbon Tetrachloride	Uranium - 235	Sodium	Manganese
	Chloroform	Uranium - 238	Strontium	Potassium
	Methylene Chloride		Thallium	Sodium
	Tetrachloroethene		Zinc	Strontium
	Trichloroethene			
	Vinyl Chloride			
SW-132	1,2-Dichloroethene	Americium - 241	Barium	Arsenic
	Acetone	Plutonium - 239,240	Cadmium	Barium
	Methylene Chloride	Uranium, Total	Calcium	Calcium
		Uranium - 233,234	Lithium	Lithium
		Uranium - 235	Magnesium	Magnesium
		Uranium - 238	Potassium	Manganese
			Selenium	Potassium
			Sodium	Selenium
			Strontium	Sodium
			Thallium	Strontium

(TAL) metals, and selected metals not included on the EPA TAL (cesium, lithium, molybdenum, silicon, strontium, and tin). However, as discussed in Section 4.2.2, only a subset of these analytes have been identified as potential contaminants (Table 4-2). The following summary is focused on only those potential contaminants for which ARARs have been identified. The complete sample collection and analytical data for all analytes at these three locations is presented in Appendix C.

4.2.3.1 Surface Water Station SW-59

The analytical results for Station SW-59 have been summarized in tabular form for all potential contaminants for which ARARs have been identified (Table 4-3). The table presents the number of samples and the number of results exceeding the method detection limit for each potential contaminant, followed by the minimum and maximum detected value, and the arithmetic mean value. ARARs and the number of samples exceeding the ARAR are also presented to assess the degree of compliance with ARARs before treatment.

Radionuclides: ARARs for americium-241, gross alpha, plutonium-239/240, and total uranium were exceeded in 2 of 12; 2 of 10; 1 of 13; and 2 of 18 samples, respectively. Gross beta results indicate no exceedance of the ARAR in 10 samples. It is noted that the mean value for each analyte is below its respective ARAR value.

Volatile Organic Compounds: Although all six of the compounds were detected at least once, carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene were consistently detected in concentrations exceeding their respective ARARs.

Vinyl chloride and 1,1-dichloroethene were detected in 1 and 16 out of 25 samples at detection limits of 10 $\mu\text{g}/\ell$ and 5 $\mu\text{g}/\ell$, respectively. In the 16 samples where 1,1-dichloroethene was detected, 7 of these samples exceeded the ARAR of 7 $\mu\text{g}/\ell$. The mean value for 1,1-dichloroethene (5.86 $\mu\text{g}/\ell$), however, does not exceed the ARAR value. It should be noted that in general, for all three stations, the method detection limits for chloroform,

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TABLE 4-3
SUMMARY OF SURFACE WATER CHARACTERIZATION
WITH SUMMARY STATISTICS FOR POTENTIAL CONTAMINANTS
STATION NUMBER SW-59

ANALYTE	NUMBER OF SAMPLES	NUMBER OF DETECTS > OR = CRQL	MINIMUM +/- ERROR	MAXIMUM +/- ERROR	MEAN	ARAR	NUMBER ABOVE ARAR
Radiochemistry (pCi/l)							
Americium-241	12	12	-0.0040 +/- 0.0100	0.1200 +/- 0.0240	0.0246	0.05	2
Gross Alpha	10	10	0.1330 +/- 1.9600	21.0000 +/- 2.5000	5.6861	11.00	2
Gross Beta	10	10	2.9180 +/- 1.1100	17.0000 +/- 3.3000	6.7979	19.00	0
Plutonium-239/240	13	13	0.0010 +/- 0.0100	0.1600 +/- 0.0260	0.0271	0.05	1
Uranium, Total	18	18	0.0660 +/- 0.0640	11.9020 +/- 3.4930	5.9681	10	2
TCL Volatiles (ug/l)							
1,1-Dichloroethene	25	16	1.00 J	11.00	5.86	7	7
Carbon Tetrachloride	25	25	16.00	200.00	122.04	5	25
Chloroform	25	25	5.00	34.00	21.84	1*	25
Tetrachloroethene	25	25	20.00	150.00	73.60	1*	25
Trichloroethene	25	25	18.00	170.00	85.20	5	25
Vinyl Chloride	25	1	2.00 J	14.00	5.16	2*	**
Dissolved Metals (ug/l)							
Iron	24	4	2.00 UE	1550.00	85.69	300	1
Manganese	25	10	1.00 U	111.00	11.04	50	1
Total Metals (ug/l)							
Aluminum	25	19	18.00 U	3950.00	827.99	200.00	16
Arsenic	23	2	0.70 U	4.30	1.28	50.00	0
Barium	25	19	84.60	211.00	172.22	1000.00	0
Beryllium	25	0	0.30 U		0.47	100.00	0
Cadmium	25	0	1.00 U		1.12	5.00	0
Chromium	25	1	2.00 U	26.60	3.15	10.00	1
Copper	24	3	1.90 U	7.40	3.11	25.00	0
Iron	25	20	11.80 U	3770.00	664.26	1000.00	4
Lead	25	14	0.80 U	6.20	2.45	5.00	4
Manganese	25	16	1.50 U	78.80	19.93	1000.00	0
Mercury	25	5	0.10 U	0.53	0.13	0.20	3
Nickel	24	1	2.60 U	36.50	6.09	40.00	0
Selenium	25	1	0.70 U	3.10	1.14	10.00	0
Zinc	25	25	72.10	400.00	255.00	50.00	25

TCL - EPA Contract Laboratory Program Target Compound List
J - Reported value is less than Contract Required Quantitation Limit, but greater than Instrument Detection Limit
U - U.S. EPA Contract Laboratory Program (CLP) Contract Required Quantitation Limit (CRQL)
Mean was calculated by uniformly replacing values below the detection limit

E - Concentration exceeds calibration range of instrument
* - ARAR below detection limits
** - Unknown; ARAR is below detection limit

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tetrachloroethene, and vinyl chloride (5 $\mu\text{g}/\ell$, 5 $\mu\text{g}/\ell$, and 10 $\mu\text{g}/\ell$, respectively) exceed each compound's respective ARARs (1 $\mu\text{g}/\ell$, 1 $\mu\text{g}/\ell$, and 2 $\mu\text{g}/\ell$). It is not possible to determine the number of samples exceeding the ARAR unless the concentration exceeds the detection limit. Note also that a comparison of mean concentrations with ARARs for each analyte is valid only for those analytes where the ARAR exceeds the method detection limit. This is because mean concentrations were calculated by applying uniform replacement values equivalent to one-half the detection limit for results below the method detection limit. Therefore, a comparison between the mean concentrations and ARARs for chloroform, tetrachloroethene, or vinyl chloride would not be useful or appropriate. The use of uniform replacement values for calculating summary statistics is described in more detail in Appendix B.

Dissolved Metals: Iron and manganese are the only dissolved metals identified in the IM/IRAP with ARARs. Four of 24 samples exhibited detectable concentrations of dissolved iron. The one sample that exceeded the ARAR of 300 $\mu\text{g}/\ell$ was also the maximum detected value of 1,550 $\mu\text{g}/\ell$. The mean dissolved iron concentration of 85.7 $\mu\text{g}/\ell$ does not exceed the ARAR. Ten of 25 manganese samples exhibited detectable concentrations, with only 1 sample exceeding the ARAR of 50 $\mu\text{g}/\ell$. The mean value for dissolved manganese of 11 $\mu\text{g}/\ell$ is below the ARAR.

Total Metals: Aluminum and zinc are the only two metals that were detected frequently (16 and 25 out of 25 samples, respectively) in concentrations exceeding their respective ARARs. Iron, lead, mercury, and chromium were detected in concentrations exceeding their respective ARAR values but less frequently (4 or less out of 25) than aluminum and zinc. Mean values for all metals except aluminum and zinc were below their respective ARARs.

4.2.3.2 Surface Water Station SW-61

The analytical results for Station SW-61 have been summarized in tabular and graphic format for all potential contaminants for which ARARs have been identified (Table 4-4 and Appendix D, respectively). Table 4-4 is formatted in a manner similar to that presented for Station SW-59. Appendix D provides a graphical representation of the analytical data collected

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TABLE 4-4
SUMMARY OF SURFACE WATER CHARACTERIZATION
WITH SUMMARY STATISTICS FOR POTENTIAL CONTAMINANTS
STATION NUMBER SW-61

ANALYTE	NUMBER OF SAMPLES	NUMBER OF DETECTS > or = CROL	MINIMUM +/- ERROR	MAXIMUM +/- ERROR	MEAN	ARAR	NUMBER ABOVE ARAR
Radiochemistry (pCi/l)							
Americium-241	18	18	-0.0050 +/- 0.0100	0.0478 +/- 0.0170	0.0099	0.05	0
Gross Alpha	14	14	1.7000 +/- 3.0000	6.4000 +/- 1.100	3.9208	11.00	0
Gross Beta	15	15	3.0410 +/- 1.0800	11.0000 +/- 1.3000	5.2998	19.00	0
Plutonium-239/240	19	19	0.0006 +/- 0.0023	0.0329 +/- 0.0237	0.0120	0.05	0
Uranium, Total	23	23	0.0480 +/- 0.0360	12.0800 +/- 1.5370	4.0575	10.00	1
TCL Volatiles (ug/l)							
1,1-Dichloroethene	30	0	5.00 U		2.50	7	0
Carbon Tetrachloride	31	13	1.00 J	14.00	5.48	5	12
Chloroform	31	0	0.80 J		2.28	1*	**
Tetrachloroethene	31	11	1.00 J	22.00	4.52	1*	**
Trichloroethene	31	12	2.00 J	32.00	5.42	5	9
Vinyl Chloride	31	2	1.00 J	37.00	6.16	2*	**
Dissolved Metals (ug/l)							
Iron	30	9	6.20 U	588.00	40.57	300	1
Manganese	31	29	2.80 U	271.00	63.67	50	19
Total Metals (ug/l)							
Aluminum	31	17	27.20	1100.00	246.95	200.00	11
Arsenic	31	0	0.50 U		0.84	50.00	0
Barium	31	26	110.00	180.00	157.84	1000.00	0
Beryllium	31	1	0.30	0.30	0.33	100.00	0
Cadmium	31	1	1.00 U	1.70	1.17	5.00	0
Chromium	31	3	2.00 U	5.50	1.89	10.00	0
Copper	30	6	1.90 U	6.10	2.43	25.00	0
Iron	31	23	34.30 U	1310.00	379.44	1000.00	2
Lead	31	16	0.70 U	8.30	2.05	5.00	2
Manganese	31	29	3.20 U	283.00	72.40	1000.00	0
Mercury	31	3	0.10 U	0.20	0.09	0.20	0
Nickel	31	1	2.60 U	2.70	4.31	40.00	0
Selenium	31	1	0.70 U	3.40	1.17	10.00	0
Zinc	31	31	40.70	250.00	123.94	50.00	29

B - Concentration exceeds calibration range of instrument

* - ARAR below detection limit

** - Unknown; ARAR is below detection limit

TCL - EPA Contract Laboratory Program Target Compound List

J - Reported value is less than Contract Required Quantitation Limit, but greater than Instrument Detection Limit

U - U.S. EPA Contract Laboratory Program (CLP) Contract Required Quantitation Limit (CROL)

Mean was calculated by uniformly replacing values below the detection limit

at Stations SW-61 and SW-132 for each of the contaminants that have designated ARARs. The graphs in Appendix D plot concentration versus time for each contaminant over the course of the treatability study.

Radionuclides: The ARAR for total uranium was exceeded only once in 23 samples. The remaining analytes were not detected in concentrations exceeding their respective ARARs. As with Station SW-59, the mean value for each analyte is below its respective ARAR.

Volatile Organic Compounds: Carbon tetrachloride and trichloroethene were detected frequently in concentrations exceeding their respective ARARs (12 of 31, and 9 of 31, respectively); however, their mean concentrations just exceed ARARs. Tetrachloroethene was detected at or above the detection limit of 5 $\mu\text{g}/\ell$ in 11 of 31 samples; however, 9 samples exhibited concentrations at estimated values between 1 and 5 $\mu\text{g}/\ell$, which is above ARAR. Vinyl chloride was detected above the method detection limit of 10 $\mu\text{g}/\ell$ less frequently (2 of 31); however, 12 samples exhibited concentrations at estimated values between 1 and 8 $\mu\text{g}/\ell$. Eight of the 12 estimated values exceed the ARAR of 2 $\mu\text{g}/\ell$. Chloroform was not detected in any samples in concentrations above the detection limit of 5 $\mu\text{g}/\ell$; however, 7 samples exhibited estimated concentrations ranging between 0.8 $\mu\text{g}/\ell$ and 3 $\mu\text{g}/\ell$. Four of the 7 estimated values exceed the ARAR of 1 $\mu\text{g}/\ell$. There were no detectable concentrations (including estimated values) of 1,1-dichloroethene in any samples.

Dissolved Metals: Nine of 30 samples exhibited detectable concentrations of dissolved iron; however, only 1 sample exceeded the ARAR at 588 $\mu\text{g}/\ell$. The mean dissolved iron concentration of 40.6 $\mu\text{g}/\ell$ is below the ARAR. Twenty-nine of 31 manganese samples exhibited detectable concentrations, with 19 samples exceeding the ARAR. The mean value for dissolved manganese of 63.7 $\mu\text{g}/\ell$ exceeds the ARAR.

Total Metals: Station SW-61 exhibited total metals results similar to Station SW-59. Aluminum and zinc are the only two metals that were detected frequently in concentrations exceeding their respective ARARs (11 of 31, and 29 of 31, respectively). Iron and lead were

also detected in concentrations exceeding their respective ARARs; however, their mean concentrations were below ARARs. Mercury and chromium were not detected in concentrations exceeding ARARs.

4.2.3.3 Surface Water Station SW-132

The analytical results for Station SW-132 have been summarized in tabular and graphic format for all potential contaminants for which ARARs have been identified. Table 4-5 presents the summarized data. The plots in Appendix D present the data for SW-61 and SW-132 in a graphical format.

Radionuclides: Gross beta and total uranium are the only analytes observed to exceed their respective ARARs. There was only one exceedance for each analyte in 14 and 22 samples. As with the other surface water stations, the mean value for each analyte is below its respective ARAR.

Volatile Organic Compounds: None of the VOCs were detected above the method detection limits in any of the 30 samples collected. Estimated values below detection limits were listed for 1,1-dichloroethene, trichloroethene, and vinyl chloride.

Dissolved Metals: Seven of 31 samples exhibited detectable concentrations of dissolved iron; however, none of the samples exceeded the ARAR. The mean dissolved iron concentration of 25.9 $\mu\text{g}/\ell$ is below the ARAR. Twenty-six of 31 manganese samples exhibited detectable concentrations, with only 5 samples exceeding the ARAR. The mean value of 40.7 $\mu\text{g}/\ell$ exceeds the ARAR for dissolved manganese.

Total Metals: Station SW-132 exhibited total metals results similar to Stations SW-59 and SW-61 except that the magnitude and frequency of exceedance of ARARs by aluminum and zinc is less relative to the other two stations. Lead and mercury were detected in concentrations

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TABLE 4-5
SUMMARY OF SURFACE WATER CHARACTERIZATION
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STATION NUMBER SW-132

ANALYTE	NUMBER OF SAMPLES	NUMBER OF DETECTS > or = CRQL	MINIMUM +/- ERROR	MAXIMUM +/- ERROR	MEAN	ARAR	NUMBER ABOVE ARAR
Radiochemistry (pCi/l)							
Americium-241	18	18	0.0000 +/- 5.7100	0.0280 +/- 0.0260	0.0089	0.05	0
Gross Alpha	14	14	2.6670 +/- 1.7600	8.7000 +/- 1.9000	4.5919	11.00	0
Gross Beta	14	14	2.2280 +/- 2.0700	23.0900 +/- 5.9000	7.0361	19.00	1
Plutonium-239/240	18	18	0.0005 +/- 0.0034	0.0220 +/- 0.0150	0.0064	0.05	0
Uranium, Total	22	22	0.0170 +/- 0.0130	10.3300 +/- 2.8500	5.4172	10.00	1
TCL Volatiles (ug/l)							
1,1-Dichloroethene	29	0	2.00 J		2.48	7	0
Carbon Tetrachloride	30	0	5.00 U		2.50	5	0
Chloroform	30	0	5.00 U		2.50	1*	0
Tetrachloroethene	30	0	5.00 U		2.50	1*	0
Trichloroethene	30	0	1.00 J		2.43	5	0
Vinyl Chloride	30	0	1.00 J		4.77	2*	0
Dissolved Metals (ug/l)							
Iron	31	7	4.00 U	220.00	25.96	300	0
Manganese	31	26	1.30 U	257.00	40.72	50	5
Total Metals (ug/l)							
Aluminum	31	15	20.70 U	1380.00	129.85	200.00	4
Arsenic	31	4	0.70	4.50	1.07	50.00	0
Barium	31	26	34.40	155.00	100.66	1000.00	0
Beryllium	31	2	0.30	0.40	0.34	100.00	0
Cadmium	31	1	1.00 U	2.20	1.25	5.00	0
Chromium	31	2	2.00 U	6.50	1.93	10.00	0
Copper	30	5	1.90 U	6.70	2.30	25.00	0
Iron	31	27	61.80	768.00	224.38	1000.00	0
Lead	30	15	0.70 U	9.80	2.32	5.00	5
Manganese	31	29	3.50	251.00	49.58	1000.00	0
Mercury	31	7	0.10	0.40	0.12	0.20	5
Nickel	30	0	2.60 U		4.49	40.00	0
Selenium	31	16	1.20 U	8.80	3.32	10.00	0
Zinc	31	25	7.20 U	116.00	31.65	50.00	3

E - Concentration exceeds calibration range of instrument

* - ARAR below detection limits

** - Unknown; ARAR is below detection limit

TCL - EPA Contract Laboratory Program Target Compound List

J - Reported value is less than Contract Required Quantitation Limit, but greater than Instrument Detection Limit

U - U.S. EPA Contract Laboratory Program (CLP) Contract Required Quantitation Limit (CRQL)

Mean was calculated by uniformly replacing values below the detection limit

exceeding their respective ARARs approximately 17% of the time; however, mean concentrations for all metals with ARARs are below their respective ARARs.

4.3 TREATMENT SYSTEM OPERATIONS

This section discusses pertinent system operational events beginning with surface water flow collection. The RRS operational history including treatment processes, mechanical problems, and chemical usage is covered in Section 4.3.2. The GAC operational history is detailed in Section 4.3.3.

4.3.1 Surface Water Flow Collection

Surface water flows were collected from three concrete sumps located at SW-59, SW-61, and SW-132 along South Walnut Creek. Surface water flow from the SW-132 sump was pumped to the SW-61 sump. SW-59 sump flow was combined with SW-61 sump flow and transferred to the FTU. A summary of the weekly and cumulative surface water flow data is presented in Table 4-6. The data indicate a total cumulative flow of 12,756,000 gallons collected over a duration of 94 weeks or approximately 650 days. This equates to a daily average flow rate of 13.5 gallons per minute.

Influent and effluent flow rates for the FTU were recorded on a weekly basis from April 29, 1992, to April 21, 1993. Influent flow rates are not available for January 27, March 31, and April 7, 1993, and for the 7-day period following November 18, 1992. Effluent flow rate is not available for the 7-day period following November 19, 1992. The FTU influent line failed and was repaired on March 3, 1993.

Magnetic flow meters were installed at SW-59 and SW-61 in July 1992. The flow meter at SW-59 functioned intermittently from November 1992 through March 1993. SW-59 piping was repaired in June 1992 and October 1992. The SW-59 seep location was disrupted in September 1992 by vehicle traffic. SW-132 piping was repaired in October 1992.

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Table 4-6

Weekly and Cumulative Surface Water Flow Data

Period, Week Ending	For the Week, 1,000 gallons	Cumulative, million gallons	
05/19/91	235	0.235	Phase I
05/26	267	0.499	
06/02	198	0.696	
06/09	277	0.973	
06/16	172	1.145	
06/23	148	1.293	
06/30	110	1.403	
07/08	116	1.518	
07/15	96	1.709	
07/22	116	1.825	
07/29	193	2.018	
08/05	132	2.151	
08/12 ³	230	2.380	
08/19	153	2.534	
08/27	129	2.567	
09/03	68	2.635	
09/10 ¹	69	2.704	
09/17	86	2.790	
09/24	61	2.850	
10/01	81	2.931	
10/08	83	3.015	
10/15	43	3.058	
10/22	44	3.102	
10/29	88	3.191	
11/05	111	3.302	

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Period, Week Ending	For the Week, 1,000 gallons	Cumulative, million gallons	
11/12	131	3.433	
11/19	236	3.669	
11/26	338	4.007	
12/03	238	4.246	
12/10	144	4.389	
12/17	92	4.481	
12/24	64	4.544	
12/31	61	4.605	
01/07/92	48	4.654	
01/14 ¹	47	4.721	
01/21	70	4.790	
01/28	54	4.844	
02/04	52	4.896	
02/11	45	4.941	
02/18	32	4.973	
02/25	33	5.007	
03/03	32	5.039	
03/10	345	5.384	
03/17	466	5.849	
03/24	397	6.247	
03/31	379	6.626	
04/07	220	6.846	
04/14	155	7.001	
04/21	192	7.193	
04/27 ¹	115	7.308	
05/05	182	7.490	Phase II
05/12	153	7.642	
05/19	133	7.776	
05/26	175	7.951	

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Period, Week Ending	For the Week, 1,000 gallons	Cumulative, million gallons	
06/02	224	8.175	
06/09	146	8.321	
06/16	147	8.468	
06/23	146	8.613	
06/30	134	8.748	
07/07	112	8.860	
07/14	106	8.966	
07/21	120	9.086	
07/28	110 (6.8) ²	9.196	
08/04	83 (7.0) ²	9.279	
08/11	91 (9.2) ²	9.370	
08/18	79 (7.8) ²	9.449	
08/26	121 (4.0) ²	9.570	
09/01 ¹	111 (5.1) ²	9.681	
09/08	71 (5.6) ²	9.752	
09/16	62 (8.0) ²	9.814	
09/23	51 (14.1) ²	9.864	
09/29	43 (9.3) ²	9.907	
10/06	41 (9.0) ²	9.949	
10/13	56 (7.7) ²	10.004	
10/20	83 (4.6) ²	10.088	
10/27	92 (3.8) ²	10.180	
11/03	150 (4.7) ²	10.330	
11/10	123 (6.8) ²	10.453	
11/17	91	10.544	
11/24	131	10.675	
12/01	129	10.804	
12/08	209	11.013	
12/15	263	11.276	

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Period, Week Ending	For the Week, 1,000 gallons	Cumulative, million gallons	
12/22	198	11.474	
12/29	147	11.621	
01/05/93	147	11.767	
01/12	89	11.856	
01/19 ¹	126	11.982	
01/26	155	12.137	
02/02	105	12.242	
02/09	129	12.371	
02/16	126	12.487	
02/23	144	12.641	
03/02	116	12.756	
Total days \approx 658		DAF ⁴ = 13.5 gpm	

- 1 Changeout of lead GAC units occurred 09/15/1991, 01/16/1992, 04/27/1992, 09/01/1992, and 01/21/1993.
- 2 Estimated flow from SW-59 alone as percent of total flow.
- 3 Operations ran for 12 hours from 08/18 to 08/29/1991, otherwise 24 hours. Baseline flows were not collected during the 12 hour shifts.
- 4 Daily average flow is calculated by dividing total cumulative flow (12,756,000 gallons) by the total days of operation (approximately 658). This equates to 13.5 gallons per minute.

SW-61 flow was bypassed around the FTU for a total of 16 hours throughout Phase II due to electrical generator problems and for a total of 33 hours because of extremely high influent flow.

The total station surface water flows, surface water collection system bypasses, durations, dates, and a mass balance cannot be determined because of the limited data due to various mechanical problems, i.e., electrical generator failure, pump failure, PLC malfunction, and flow meter failure.

4.3.2 Operational History of RRS

The RRS processed approximately 12.7 million gallons of surface flow through the FTU during Phase II operations. Two days of downtime occurred from electrical generator problems, and 1 day of downtime occurred when leaking GAC vessels were taken off line. Appendix G, OU2 IM/IRA Treatment Unit Operational History, provides a weekly breakdown of RRS downtime, surface flow treated, chemical usage, membrane filter cleaning activities, sludge generation, and other operational parameters.

4.3.2.1 Total Alkalinity Reduction

Flow from the equalization tank is pumped to the first reaction tank (TK-1) and acidified by adding ferric sulfate and recycled membrane cleaning solution consisting of sulfuric acid and freshly prepared 10% sulfuric acid solution from the mixing tank. The pH at TK-1 is monitored and used to control the amount of ferric sulfate for the specified acidification. As of April 21, 1993, roughly 1,992 pounds of ferric sulfate have been used by the RRS.

Ferric sulfate is currently added to TK-1 at a concentration determined by the influent turbidity. The turbidity meter was installed January 20, 1993. Prior to this date and during the first 3 weeks of operation, ferric sulfate was added at a dose of 15 ppm. Because of voluminous sludge

production, the RRS vendor was consulted and a dose of 7.5 ppm was established. The ferric sulfate dose is now varied in accordance with Table 4-7.

Table 4-7

Ferric Sulfate Concentrations Based on Influent Turbidity

Influent Turbidity (NTU)	Ferric Sulfate Concentration (ppm)
0 - 25	7.5
26 - 50	15.0
> 50	22.5

4.3.2.2 Precipitation

Acidification in TK-1 is followed by precipitation in TK-2 as previously discussed in Section 2.1.2. The lime slurry increases the solids amount and scouring action in the membrane filter circuit. Approximately 19,350 pounds of lime have been used by the RRS as of April 21, 1993.

4.3.2.3 Sludge Generation

The slurry of precipitated, co-precipitated, and flocculated solids overflows from TK-2 into the concentration tank (TK-8) where solids form a sludge. Sludge is pumped from TK-8 to the sludge holding tank, TK-12. After a 12-hour settling period, TK-12 is bottom-pumped to the filter press. Supernatant liquid is returned to TK-8 during periods of sludge processing. After filter cake formation, the filter press is opened and sludge is dropped into 55-gallon storage drums. Sixty-three drums of sludge have been produced during Phase II to date.

RRS sludge may contain precipitated metals and radionuclides. The available characterization data presented in Appendix H is incomplete at this time; RRS sludge is being sampled, packaged, and stored as a low-level, mixed waste pending further analysis.

4.3.2.4 Crossflow Filtration and Filter Membrane Cleaning

The crossflow filtration equipment is described in Section 2.1.2. Filtration is accomplished by recirculating the slurry through the crossflow membrane and back to the concentration tank (TK-8). Treated filtrate is continuously drawn off from the filter and pumped to the neutralization tank (TK-11).

The RRS is shut down during a 2-hour filter membrane cleaning. The cleaning cycle is initiated at approximately 2-week intervals or when the filtrate flux through the membrane slows to a rate of less than 40 gpm. The cleaning schedule varies due to weather conditions but usually can be maintained during high or turbid flow conditions. Thirty-two cleaning cycles have been conducted as of April 21, 1993, during Phase II operations.

Initially, a sodium hypochlorite solution was used as a membrane cleaning chemical. This solution failed to restore the membrane after the first three cleaning cycles. Sulfuric acid was used alternately in conjunction with sodium hypochlorite for six subsequent cleaning cycles. This method was discontinued in favor of an acidified hydrogen peroxide solution due to chemical incompatibility problems. Acidified hydrogen peroxide provided adequate membrane cleaning and was used for the remainder of Phase II activities.

4.3.2.5 Filtrate Neutralization

Filtrate from the crossflow membrane filtration system is collected in TK-11. A 10-20% acid solution is added to adjust the pH to slightly above 7.0; the treated water is then pumped from the RRS into the GAC for removal of VOCs.

4.3.3 Operational History of GAC System

A new GAC vessel was installed for the Phase II program on May 1, 1992. GAC changeouts were scheduled for 120 day intervals. Pinhole leaks were discovered in the GAC vessels during

the 7-day period following August 5, 1992. The leaking GAC vessels were taken off line and replaced during the 7-day period following August 26, 1992. New GAC vessels were also installed on January 16, 1993 as part of normal maintenance operations. No other GAC changeouts occurred during the remainder of Phase II operations. All spent GAC vessels are being stored as low-level mixed wastes pending further analysis.

4.4 TREATMENT SYSTEM PERFORMANCE

Treatment system performance is presented in five subsections according to the contaminant chemical classes treated and the treatment units under consideration. Section 4.4.1 is a summary of the overall effectiveness of the FTU in treating radionuclides, VOCs, and metals in collected surface water (RS1 vs. RS7). Section 4.4.2 is a summary of the effect of the Equalization Tank (RS1 vs. RS2) on radionuclides and metals (no VOC samples were collected at RS-2). Section 4.4.3 discusses the removal of contaminants by the RRS. Section 4.4.4 summarizes VOC removal in the FTU before the GAC system (RS1 vs. RS5) and by the GAC system (RS5 vs. RS7).

4.4.1 Overall FTU Performance

Tables 4-8 through 4-10 present summary statistics for all analytes with ARARs for stations RS1 (influent taken as a composite at the collection sumps), RS5 (RRS effluent/GAC influent), and RS7 (effluent), respectively. Table 4-11 further summarizes the mean analyte concentrations at these stations and presents removal percentages based on mean concentrations. The removal percentages are only rough approximations of the actual performance of the treatment system because the data for each station are not always correlated in time.

Appendices E-1, E-2, and E-3 present summary statistics of FTU process data (analytes with ARARs) at each station for radionuclides, metals, and VOCs, respectively. Appendices F-1, F-2, and F-3 present similar concentration vs. time graphs for these process data.

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TABLE 4-8
SUMMARY OF PROCESS WATER CHARACTERIZATION
WITH SUMMARY STATISTICS FOR POTENTIAL CONTAMINANTS
STATION NUMBER RS1

ANALYTE	NUMBER OF SAMPLES	NUMBER OF DETECTS > or = CRQL	MINIMUM +/- ERROR	MAXIMUM +/- ERROR	MEAN	ARAR	NUMBER ABOVE ARAR
Radiochemistry (pCi/l)							
Americium-241	31	31	0.0016 +/- 0.0029	0.0259 +/- 0.0084	0.0085	0.05	0
Gross Alpha	30	30	1.1150 +/- 1.3800	9.7140 +/- 3.9700	4.5205	11.00	0
Gross Beta	30	30	-1.2600 +/- 10.9000	14.7000 +/- 3.1900	6.6472	19.00	0
Plutonium-239/240	31	31	0.0009 +/- 0.0035	0.0615 +/- 0.0300	0.0098	0.05	1
Uranium, Total	28	28	1.8859 +/- 0.8416	14.7504 +/- 3.2790	6.3318	10.00	1
TCL Volatiles (ug/l)							
1,1-Dichloroethene	6	1	5.00 U	7.00	3.25	7	0
Carbon Tetrachloride	6	6	5.00	130.00	29.50	5	5
Chloroform	6	1	3.00 J	22.00	5.83	1	1
Tetrachloroethene	6	4	3.00 J	89.00	21.50	1	4
Trichloroethene	6	6	5.00	110.00	27.00	5	4
Vinyl Chloride	6	0	10.00 U		5.00	2	0
TCL Volatiles EPA Method 524.2 (ug/l)							
1,1-Dichloroethene	24	13	0.10 J	2.00	0.51	7	0
Carbon Tetrachloride	24	23	0.40	55.00	14.30	5	15
Chloroform	24	23	0.10 U	12.00	3.64	1	18
Tetrachloroethene	24	21	0.10 J	32.00	6.72	1	18
Trichloroethene	24	23	0.20	32.00	9.96	5	13
Vinyl Chloride	24	11	0.20 U	4.00	0.65	2	1
Dissolved Metals (ug/l)							
Iron	24	5	3.50 B	243.00	57.44	300.00	0
Manganese	24	23	4.70 B	49.40	28.03	50.00	0
Total Metals (ug/l)							
Aluminum	33	13	18.00 U	1050.00	251.36	200.00	13
Arsenic	33	0	1.00 U		0.71	50.00	0
Barium	33	0	81.90 B		144.39	1000.00	0
Beryllium	33	0	1.00 U		0.65	100.00	0
Cadmium	33	0	2.00 U		1.16	5.00	0
Chromium	33	0	2.00 U		1.96	10.00	0
Copper	33	2	2.00 U	34.10	4.61	25.00	2
Iron	33	29	12.80 U	1380.00	399.03	1000.00	3
Lead	33	2	1.00 U	12.30	1.30	5.00	1
Manganese	33	32	11.00 B	85.40	35.32	1000.00	0
Mercury	33	0	0.20 U		0.10	0.20	0
Nickel	33	0	3.00 B		3.11	40.00	0
Selenium	33	0	1.00 BN		1.67	10.00	0
Zinc	33	33	44.20	256.00	121.99	50.00	32

J - Reported value is less than Contract Required Detection Limit (CRDL) but greater than Instrument Detection Limit
N - Spills sample recovery not within control limits
U - U.S. EPA Contract Laboratory Program (CLP) CRDL
W - Post-digestion spills out of control limits

TCL - EPA Contract Laboratory Program Target Compound List
Mean was calculated by uniformly replacing values below the detection limit
B - For inorganic reported values is less than CRDL, but greater than IDL
BN - Result is estimated

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TABLE 4-9
SUMMARY OF PROCESS WATER CHARACTERIZATION
WITH SUMMARY STATISTICS FOR POTENTIAL CONTAMINANTS
STATION NUMBER RS5

ANALYTE	NUMBER OF SAMPLES	NUMBER OF DETECTS > or = CRQL	MINIMUM +/- ERROR	MAXIMUM +/- ERROR	MEAN	ARAR	NUMBER ABOVE ARAR
Radiochemistry (pCi/l)							
Americium-241	27	27	0.0000 +/- 0.0199	0.0099 +/- 0.0064	0.0039	0.05	0
Gross Alpha	24	24	-0.2050 +/- 1.3200	10.9800 +/- 3.9000	3.0275	11.00	0
Gross Beta	24	24	0.1895 +/- 2.9900	10.8400 +/- 2.5700	5.3405	19.00	0
Plutonium-239/240	26	26	-0.0015 +/- 0.0015	0.0268 +/- 0.0156	0.0027	0.05	0
Uranium, Total	24	24	0.0593 +/- 0.2718	9.2622 +/- 2.5040	3.1973	10.00	0
TCL Volatiles (ug/l)							
1,1-Dichloroethene	6	0	5.00 U		2.50	7	0
Carbon Tetrachloride	6	0	1.00 J		2.17	5	0
Chloroform	6	2	5.00 U	100.00	19.67	1	2
Tetrachloroethene	6	0	3.00 J		2.58	1	0
Trichloroethene	6	0	2.00 J		2.42	5	0
Vinyl Chloride	6	0	10.00 U		5.00	2	0
TCL Volatiles EPA Method 524.2 (ug/l)							
1,1-Dichloroethene	24	0	0.20 U		0.13	7	0
Carbon Tetrachloride	24	10	0.20 U		0.35	5	0
Chloroform	24	12	0.10	0.90	0.68	1	4
Tetrachloroethene	24	6	0.10 U	1.00	0.19	1	0
Trichloroethene	24	7	0.10	2.00	0.28	5	0
Vinyl Chloride	24	4	0.20	1.00	0.15	2	0
Dissolved Metals (ug/l)							
Iron	21	0	3.00 U		20.75	300.00	0
Manganese	23	5	1.00 U		9.07	50.00	1
Total Metals (ug/l)							
Aluminum	31	0	12.00 U		46.36	200.00	0
Arsenic	31	0	1.00 U		0.59	50.00	0
Barium	31	0	27.40 BE		64.30	1000.00	0
Beryllium	31	0	1.00 U		0.66	100.00	0
Cadmium	31	0	2.00 U		1.11	5.00	0
Chromium	31	0	2.00 U		1.87	10.00	0
Copper	31	1	2.00 U	32.60	2.40	25.00	1
Iron	31	5	2.00 UE	730.00	86.42	1000.00	0
Lead	31	0	1.00 U		0.55	5.00	0
Manganese	31	6	1.00 U	69.50	9.81	1000.00	0
Mercury	31	0	0.20 U		0.10	0.20	0
Nickel	31	0	3.00 U		2.44	40.00	0
Selenium	31	0	1.00 UW		1.93	10.00	0
Zinc	30	3	4.60 B	28.60	10.16	50.00	0

J. Reported value is less than Control Required Detection Limit (CRDL) but greater than Instrument Detection Limit
N. Spike sample recovery not within control limits
U. U.S. EPA Control Laboratory Program (CLP) CRDL
W. Post-digestion spike out of control limits

TCL. EPA Control Laboratory Program Target Compound List
Mean was calculated by uniformly replacing values below the detection limit
B. For inorganic reported values is less than CRDL, but greater than EDL
E. Result is estimated

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TABLE 4-10
SUMMARY OF PROCESS WATER CHARACTERIZATION
WITH SUMMARY STATISTICS FOR POTENTIAL CONTAMINANTS
STATION NUMBER RS7

ANALYTE	NUMBER OF SAMPLES	NUMBER OF DETECTS > or = CRQL	MINIMUM +/- ERROR	MAXIMUM +/- ERROR	MEAN	ARAR	NUMBER ABOVE ARAR
Radiochemistry (pCi/l)							
Americium-241	26	26	-0.0003 +/- 0.0005	0.0965 +/- 0.0718	0.0080	0.05	1
Gross Alpha	24	24	-1.4700 +/- 2.7200	6.4440 +/- 2.9900	1.4556	11.00	0
Gross Beta	24	24	1.2760 +/- 1.7800	13.0700 +/- 2.9500	5.4196	19.00	0
Plutonium-239/240	27	27	-0.0008 +/- 0.0010	0.3968 +/- 0.1760	0.0162	0.05	1
Uranium, Total	25	25	0.0188 +/- 0.2292	5.4187 +/- 1.6269	1.1952	10.00	0
TCL Volatiles (ug/l)							
1,1-Dichloroethene	6	0	5.00 U		2.50	7	0
Carbon Tetrachloride	6	0	5.00 U		2.50	5	0
Chloroform	6	0	5.00 U		2.50	1	0
Tetrachloroethene	6	0	5.00 U		2.50	1	0
Trichloroethene	6	0	5.00 U		2.50	5	0
Vinyl Chloride	6	0	10.00 U		5.00	2	0
TCL Volatiles EPA Method 824.3 (ug/l)							
1,1-Dichloroethene	23	0	0.20 U		0.13	7	0
Carbon Tetrachloride	23	0	0.10 J		0.16	5	0
Chloroform	23	2	0.10	0.30	0.06	1	0
Tetrachloroethene	23	0	0.10 J		0.08	1	0
Trichloroethene	23	1	0.10 U	0.20	0.09	5	0
Vinyl Chloride	23	0	0.20 U		0.10	2	0
Dissolved Metals (ug/l)							
Iron	23	0	3.00 U		20.19	300.00	0
Manganese	23	9	1.00 U	251.00	24.50	50.00	2
Total Metals (ug/l)							
Aluminum	31	4	18.00 U	425.00	93.98	200.00	4
Arsenic	31	0	1.00 U		0.80	50.00	0
Barium	31	0	24.70 BE		65.14	1000.00	0
Beryllium	31	0	1.00 U		0.69	100.00	0
Cadmium	31	0	2.00 U		1.20	5.00	0
Chromium	31	0	2.00 U	35.20	1.77	10.00	0
Copper	31	1	2.00 U		2.37	25.00	1
Iron	30	7	2.00 UB	498.00	67.00	1000.00	0
Lead	31	1	1.00 U		0.87	5.00	1
Manganese	31	14	1.00 U	11.10	24.82	1000.00	0
Mercury	31	0	0.20 U	256.00	0.10	0.20	0
Nickel	31	0	3.00 U		3.31	40.00	0
Selenium	31	0	1.00 UN		1.78	10.00	0
Zinc	30	10	4.60 B	131.00	20.46	50.00	2

TCL: EPA Contract Laboratory Program Target Compound List
Mean was calculated by uniformly replacing values below the detection limit
B - Per isotope reported value is less than CRDL, but greater than EDL
B - Result is estimated
J - Reported value is less than Contract Required Detection Limit (CRDL) but greater than Instrument Detection Limit
N - Spills sample recovery not within control limits
U - U.S. EPA Contract Laboratory Program (CLP) CRDL
W - Post-digestion spike out of control limits

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TABLE 4-11
OVERALL SUMMARY OF PROCESS WATER CHARACTERIZATION

ANALYTE	ARAR	RS1		RS5		RS7		MEAN REMOVAL EFFICIENCY (%)		
		MEAN	NUMBER ABOVE ARAR/ NUMBER SAMPLES	MEAN	NUMBER ABOVE ARAR/ NUMBER SAMPLES	MEAN	NUMBER ABOVE ARAR/ NUMBER SAMPLES	RS1 v RS5	RS5 v RS7	RS1 v RS7
Radiochemistry (pCi/l)										
Americium-241	0.05	0.0085	0/31	0.0039	0/27	0.0080	1/26	54	•	5.9
Gross Alpha	11.00	4.5205	0/30	3.0275	0/24	1.4556	0/24	33	52	67.8
Gross Beta	19.00	6.6472	0/30	5.3405	0/24	5.4196	0/24	19.7	•	18.5
Plutonium-239/240	0.05	0.0098	1/31	0.0027	0/26	0.0162	1/27	72.4	•	•
Uranium, Total	10.00	6.3318	1/28	3.1973	0/24	1.1952	0/25	49.5	62.6	81.1
TCL Volatiles (ug/l)										
1,1-Dichloroethene	7	3.25	0/6	2.50	0/6	2.50	0/6	23	0	23
Carbon Tetrachloride	5	29.50	0/6	2.17	0/6	2.50	0/6	92.6	•	91.5
Chloroform	1	5.83	1/6	19.67	2/6	2.50	0/6	•	87.3	57.1
Tetrachloroethene	1	21.50	4/6	2.58	0/6	2.50	0/6	88	3.1	88.4
Trichloroethene	5	27.00	4/6	2.42	0/6	2.50	0/6	91	•	90.7
Vinyl Chloride	2	5.00	0/6	5.00	0/6	5.00	0/6	0	0	0
TCL Volatiles EPA Method 524.2 (ug/l)										
1,1-Dichloroethene	7	0.51	0/24	0.13	0/24	0.13	0/23	74.5	0	74.5
Carbon Tetrachloride	5	14.30	15/24	0.35	0/24	0.16	0/23	97.6	54.3	98.9
Chloroform	1	3.64	18/24	0.68	4/24	0.06	0/23	81.3	91.2	98.4
Tetrachloroethene	1	6.72	18/24	0.19	0/24	0.08	0/23	97.2	57.9	98.8
Trichloroethene	5	9.96	13/24	0.28	0/24	0.09	0/23	97.2	67.9	99.1
Vinyl Chloride	2	0.65	11/24	0.15	0/24	0.10	0/23	76.9	33.3	84.6
Dissolved Metals (ug/l)										
Iron	300.00	57.44	0/24	20.75	0/21	20.19	0/23	63.9	2.7	64.9
Manganese	50.00	28.03	0/24	9.07	1/23	24.50	2/23	67.6	•	12.6
Total Metals (ug/l)										
Aluminum	200.00	251.36	13/33	46.36	0/31	93.98	4/31	81.6	•	62.6
Arsenic	50.00	0.71	0/33	0.59	0/31	0.80	0/31	16.9	•	•
Barium	1000.00	144.39	0/33	64.30	0/31	65.14	0/31	55.5	•	54.9
Beryllium	100.00	0.65	0/33	0.66	0/31	0.69	0/31	•	•	•
Cadmium	5.00	1.16	0/33	1.11	0/31	1.20	0/31	4.3	•	•
Chromium	10.00	1.96	0/33	1.87	0/31	1.77	0/31	4.6	5.3	9.7
Copper	25.00	4.61	2/33	2.40	1/31	2.37	1/31	47.9	1.2	48.6
Iron	1000.00	399.03	3/33	86.42	0/31	67.00	0/30	78.3	22.5	83.2
Lead	5.00	1.30	1/33	0.55	0/31	0.87	1/31	57.7	•	33.1
Manganese	1000.00	35.32	0/33	9.81	0/31	24.82	0/31	72.2	•	29.7
Mercury	0.20	0.10	0/33	0.10	0/31	0.10	0/31	0	0	0
Nickel	40.00	3.11	0/33	2.44	0/31	3.31	0/31	21.5	•	•
Selenium	10.00	1.67	0/33	1.93	0/31	1.78	0/31	•	7.8	•
Zinc	50.00	121.99	32/33	10.16	0/30	20.46	2/30	91.7	•	83.2

* In these cases, mean effluent concentrations exceed mean influent concentrations. This indicates removal of the analyte is not occurring and should not imply that the analyte is being added to the water by way of treatment.
This "error" is due to the quantitation of low concentrations of analytes and/or the inherent error of comparative analysis using mean concentrations.

4.4.1.1 Radionuclide Removal

The influent and effluent treatment system data indicate radionuclides contributing to gross alpha activity were removed as was uranium (refer to corresponding figures in Appendix F-1). Gross alpha activity was reduced by 67.8% whereas uranium removal was 81.1% (Table 4-11). The data do not show obvious removal of other radionuclides because influent concentrations were low. In terms of ARARs, one plutonium-239/240 FTU effluent (RS7) sample was above ARAR; however, the corresponding FTU influent (RS1) sample was below ARAR. One americium-241 FTU effluent (RS7) sample was above ARAR, but, none of the FTU influent samples (RS1) were above ARAR.

4.4.1.2 VOC Removal

The influent and effluent treatment system data indicate that volatiles are effectively removed (Table 4-11). Based on EPA Method 524.2 data (low detection limits), the range of VOC removal is 74.5% (1,1 DCE) to 99.1% (TCE). With respect to ARARs, carbon tetrachloride, chloroform, tetrachloroethene, trichloroethene, and vinyl chloride exhibited concentrations above ARARs at RS1 (Tables 4-8 and 4-11). No VOC analytes exceeded ARARs at RS7 (Tables 4-10 and 4-11). All RS7 analytes except chloroform and trichloroethene were either not detected or exhibited estimated values below the Contract Required Detection Limit (CRDL).

4.4.1.3 Metals Removal

Metal removal efficiencies vary from 0% to as high as 83.2% (Table 4-11). Metals with the highest removal efficiency ($\approx 50\%$ to 83.2%) include aluminum, barium, copper, iron, and zinc. Metals with low removal efficiencies are chromium, lead, and manganese (9.7% to 33.1%). The data do not indicate any removal of arsenic, beryllium, cadmium, nickel, and selenium. With respect to ARARs, aluminum, copper, iron, lead, and zinc concentrations were above ARARs at RS1. Aluminum, copper, lead, manganese, and zinc concentrations were only rarely above ARARs at RS7, and the mean concentrations were all below ARARs.

4.4.2 Equalization Tank

Section 4.4.2 discusses removal of radionuclides and metals from collected surface waters by the equalization tank. Removal of these contaminants would occur from particle settling and adhesion to the tank walls. No VOC samples were collected at RS2.

4.4.2.1 Radionuclide Removal

Graphs of radionuclide concentrations vs. time for RS1 and RS2 (Appendix F-1) do not indicate significant removal of radionuclides across the equalization tank. Although there is considerable "noise" in the data presentation, each graph appears to indicate some radionuclide removal is occurring. Table 4-12 shows there were only rare exceedances of ARARs at RS1 and RS2.

4.4.2.2 Metals Removal

Review of the concentration vs. time graphs for the metals (Appendix F-2) indicates little if any removal of metals across the equalization tank. With respect to ARARs, there are many occurrences of analytes exceeding ARARs at either RS1 or RS2, particularly for aluminum and zinc (Table 4-13). These data (Table 4-13) also indicate some aluminum and zinc removal is occurring across this unit.

4.4.3 RRS

4.4.3.1 Radionuclides Removal

The concentration vs. time graphs for radionuclides at RS2 and RS5 (Appendix F-1) indicate plutonium and to a lesser extent americium and uranium are removed by the RRS (refer also to Table 4-11, RS1 vs. RS5). Although such removal is expected, the low overall removal (Table 4-11, RS1 vs. RS7) of plutonium and americium across the entire treatment system renders any conclusion about radionuclide removal by the RRS suspect. Also note there is apparent

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Table 4-12

Summary of Radionuclides Exceeding ARARs for RS1 and RS2

Analyte	ARAR (pCi/l)	Sample Location RS1 ¹ (pCi/l)	Sample Location RS2 ² (pCi/l)	Sample Date
Total Pu-239/240	0.05	0.0615 +/-0.03	0.0084 +/-0.0058	06/02/92
Total Uranium	10.00	14.7504 +/-3.279	NA	06/16/92

NA = Not Available, RS2 sampled monthly, RS1 sampled weekly.

¹ = RS1 collected from surface water collection sumps and therefore represents influent to the Equalization Tank.

² = RS2 is effluent from the Equalization Tank.

Table 4-13

Summary of Metals Exceeding ARARs for RS1 and RS2

Analyte	ARAR (µg/l)	Sample Location RS1 ¹ (µg/l)	Sample Location RS2 ² (µg/l)	Sample Date
Dissolved Manganese	50.00	28.60 20.50	81.80 64.20	07/21/92 11/03/92
Total Aluminum	200.00	346.00 594.00 391.00 281.00 1,040.00 1,050.00 423.00 421.00 212.00 248.00 371.00 238.00	127.00 86.40 79.70 NA NA 1,280.00 NA NA 58.80 NA NA NA	05/26/92 06/02/92 06/09/92 06/16/92 10/27/92 11/03/92 11/24/93 12/01/92 12/21/92 01/26/93 02/02/93 02/09/93
Total Copper	25.00	34.10 25.20	33.90 NA	05/05/92 12/01/92
Total Iron	1,000.00	1,340.00 1,340.00	NA 1,540.00	10/27/92 11/03/92

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Table 4-13 (Continued)

Summary of Metals Exceeding ARARs for RS1 and RS2

Analyte	ARAR ($\mu\text{g}/\ell$)	Sample Location RS1 ¹ ($\mu\text{g}/\ell$)	Sample Location RS2 ² ($\mu\text{g}/\ell$)	Sample Date
Dissolved Manganese	50.00	28.60	81.80	07/21/92
			64.20	11/03/92
		20.50		
Total Zinc	50.00	137.00	122.00	05/05/92
		110.00	81.70	05/19/92
		163.00	107.00	05/26/92
		139.00	109.00	06/02/92
		202.00	131.00	06/09/92
		187.00	NA	06/16/92
		200.00	NA	06/23/92
		256.00	NA	07/07/92
		130.00	NA	07/14/92
		215.00	162.00	07/21/92
		151.00	NA	07/28/92
		115.00	54.10	08/04/92
		73.20	63.40	08/28/92
		76.20	40.30	10/12/92
		131.00	NA	10/20/92
		133.00	NA	10/27/92
		91.00	103.00	11/03/92
		61.60	NA	11/10/92
		117.00	NA	11/24/92
		123.00	NA	12/01/92
		79.40	NA	12/08/92
		108.00	NA	12/15/92
		112.00	84.10	12/21/92
		73.20	NA	12/28/92
		95.30	74.70	01/05/93
		95.30	NA	01/19/93
		88.20	NA	01/26/93
		101.00	NA	02/02/93
		117.00	NA	02/09/93

NA = Not Available, RS2 sampled monthly, RS1 sampled weekly.

¹ = RS1 collected from surface water collection sumps and therefore represents influent to the Equalization Tank.

² = RS2 is effluent from the Equalization Tank.

significant removal of uranium across the GAC units (Table 4-11, RS5 vs. RS7). Such removal by GAC is unexpected but nevertheless contributes to the high overall uranium removal by the treatment system. No radionuclides exceeded ARARs in the RRS influent (RS2) or RRS effluent (RS5).

4.4.3.2 Metals Removal

The concentration vs. time graphs for metals at RS2 and RS5 (Appendix F-1) indicate some metals are removed by the RRS, particularly aluminum, barium, iron, lead, manganese, and zinc. Removal efficiencies for these metals range from 55.5% (barium) to 91.7% (zinc). Other metals were removed to a lesser extent, and there is no apparent removal of beryllium or selenium. All metals which had RS2 values greater than ARAR were reduced to below ARARs at RS5 by the RRS, except for copper which showed only a slight decrease (Table 4-14).

4.4.4 VOC Removal

EPA CLP Method 502.2 and EPA Method 524.2 were used to analyze samples from the influent line to the GAC system (RS5) and from the GAC system discharge (RS7) to the South Walnut Creek drainage. The EPA CLP method lacked enough sensitivity to distinguish the low VOC concentrations in the process water; consequently, most of the values reported by the CLP method were at the CRDL.

4.4.4.1 VOC Removal Before GAC System

Data resulting from the use of EPA Method 524.2 indicate significant VOC removal prior to treatment by GAC (Table 4-11). Removal of VOCs presumably occurs by volatilization via aeration/mixing that occurs in the process lines, the equalization tank, and the RRS. With respect to ARARs, carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene were detected above ARARs at RS1. 1,1-Dichloroethene had only one detect at the ARAR level at

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RS1 using the CLP method at RS1 and RS5. Chloroform was the only VOC analyte that had a value greater than ARAR at RS5.

4.4.4.2 VOC Removal in GAC System

GAC further removes residual VOCs present after treatment by the RRS (Appendix F-3 and Table 4-11). There are no exceedances of ARARs for VOCs in the effluent from the GAC, whereas, there were 4 of 25 exceedances of ARAR for chloroform in the influent to the GAC. Although VOC removal occurs in the GAC units, it is worthy to note that, with the exception of chloroform, the organics did not exceed ARAR in the influent to the GAC. This calls into question the utility of the GAC treatment.

Table 4-14
Summary of Metals Exceeding ARARs for RS2 vs. RS5

Analyte	ARAR ($\mu\text{g}/\ell$)	Sample Location RS2 ¹ ($\mu\text{g}/\ell$)	Sample Location RS5 ² ($\mu\text{g}/\ell$)	Sample Date
Dissolved Manganese	50.00	81.80	20.50	07/21/92
		64.20	5.60	11/03/92
Total Aluminum	200.00	1,280.00	22.60	11/03/92
Total Copper	25.00	33.90	32.60	05/05/92
Total Iron	1000.00	1,540.00	730.00	11/03/92
Total Zinc	50.00	122.0	25.20	05/05/92
		81.70	14.90	05/19/92
		107.00	14.30	05/26/92
		109.00	8.60	06/02/92
		131.00	15.40	06/09/92
		162.00	8.50	07/21/92
		54.10	11.90	08/04/92
		63.40	5.90	08/28/92
		103.00	28.60	11/03/92
		84.10	4.80	12/21/92
		74.70	10.20	01/05/93

¹ = RS2 is effluent from the Equalization Tank and influent to the RRS.

² = RS5 is effluent from the RRS.

4.5 COST ANALYSIS

Treatability study costs for Phase II are presented in Table 4-15. Included in the table are capital costs, operations and maintenance costs, and analytical services costs. Capital costs include the design, fabrication, delivery, installation, and startup of the RRS. The Phase I system included the collection system (for SW-59 and SW-61), the equalization tank and GAC system. The Phase II system incorporated the RRS and collection of SW-132. Operations and maintenance includes daily operation of the system based on a 24 hr/day, 7 days/week schedule. Operating costs include treatment system operation (labor), process chemicals requirements, sampling (labor, materials, and sample shipping), record keeping, vehicle and machinery rental, office trailer rental, personnel protective equipment requirements, chemical spill response (labor and treatment costs) and sludge production and storage. Maintenance costs include treatment system maintenance and repairs, generator servicing and repairs, repair supplies, and generator diesel fuel requirements. Analytical services costs include those for laboratory analyses and data validation.

The costs presented in Table 4-15 are estimates and are conservatively low. EG&G labor is not included in the capital or operation and maintenance estimates. The total cost of capital (not amortized) and other costs for Phase II is \$2,115,000. The Phase II costs are based on a reporting period from 27 April 1992 to 2 March 1993.

Table 4-15

Phase II Treatability Cost Summary

<u>Item</u>	<u>Cost-Phase II</u>
Capital	\$ 950,000
Operations and Maintenance	\$1,100,000
Analytical Services	\$ 654,000
Total Costs	\$2,115,000

4.5.1 Water Treatment Costs

Costs for treating a unit volume of water or for removing a unit mass of contaminant have been estimated (Table 4-16). Contaminant mass removals were estimated using mean influent and effluent concentration data and the total volume of water processed. Radionuclide activity concentrations were converted to mass/volume concentrations using their respective specific activities. The mass of sludge produced and GAC used was obtained from the operational history (Appendix G). The total costs of Phase II are listed in Table 4-16. Unit cost per pound of contaminant removed was calculated by dividing the total cost by the mass of contaminant removed. Unit costs for operation include \$166/1,000 gallons water treated, \$2,700,000/pound total radionuclides removed, \$29,000/pound total metals removed, and \$557,000/pound total VOCs removed.

4.5.2 Residuals Costs

Residuals include primarily ferric hydroxide sludge and spent GAC. Approximately 26,000 pounds of sludge and 6,000 pounds of spent GAC were produced during the Phase II reporting period. This material is being managed as a low-level, mixed waste. Costs associated with this waste include packaging, handling, monitoring, and transporting the wastes to RFP interim storage areas, in accordance with RCRA requirements. The cost of temporarily storing these residuals for up to 30 years (pending availability of a permanent TSD facility) has not yet been determined. Final treatment and/or disposal is anticipated to cost \$2,000 per 55-gallon drum of sludge disposed and \$0.50 to \$1.00 per pound of GAC regenerated.

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Table 4-16

**Treatment Costs and Residuals Production
for Phase II**

	Total RADs ^a (pCi/l)	Total Metals (µg/l)	Total VOCs (µg/l)
Average Concentration In	6.3318	967.36	35.78
Average Concentration Out	1.1952	284.29	0.62
Change in Concentration	5.1366	683.07	35.16
Gallons Water Treated	12,756,000	12,756,000	12,756,000
	(nCi)	(lbs)	(lbs)
Mass of Analytes Removed	0.81	73.91	3.80
Mass of Sludge Produced (pounds)	26,000	26,000	
Mass of Carbon Used (pounds)			6,000
Pounds Sludge/Pound RADs Removed	0.03		
Pounds Sludge/Pounds Metals Removed		352	
Pounds GAC Used/Pounds VOC Removed			1,579
Total Cost of Phase II	2,115,000		
Capital-RRS	950,000		
Capital-GAC	Phase I Cost		
Other Costs	1,165,000		
Costs (\$)/1,000 Gallons Water Treated	166		
Cost (\$)/lb Total RADs Removed	2,700,000		
Cost (\$)/lb Total Metals Removed		29,000	
Cost (\$)/lb Total VOCs Removed			557,000

^a Mass of Radionuclides removed is due primarily to uranium removal.

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Other forms of residuals include contaminated PPE, generator solid wastes, and air emissions from the diesel fuel burned by the generator. Diesel fuel consumption has averaged approximately 1,200 gallons/week since the beginning of Phase II. Associated air emissions per 1,000 gallons of diesel fuel consumed are estimated* to be:

Particulates	33.5	lbs
SO _x	31	lbs
NO _x	469	lbs
VOCs	32	lbs
CO	102	lbs

* EPA. 1990

SECTION 5

EVALUATION OF PROPOSED MODIFICATIONS TO SURFACE WATER COLLECTION

Contrary to information provided in the IRAP (DOE, 1991), the collection and treatment system has been processing surface water that exhibits relatively low levels of contamination. In particular, surface water collected from SW-61 and SW-132 has low contamination levels, but contributes the majority of the total flow to the treatment system. These two flows serve to dilute the higher contamination (both organic and radiochemical) levels in the seep water at SW-59. As a result, the overall reduction in contamination levels due to treatment is small for the organic contaminants and imperceptible for the radionuclides. The purpose of this section is to evaluate the need for continued collection and treatment of surface water flow from SW-61, SW-132, and SW-59. Exceedance of ARARs, potential public health risks, and other factors are assessed in order to support a risk management decision pertaining to the continued collection and treatment of these waters.

5.1 COMPLIANCE WITH ARARS

Table 5-1 presents a summary of the analytes at each surface water station that were detected above the ARAR value at a frequency of 10 percent or greater. This table illustrates that the relative degree of contamination is highest at Station SW-59 and lowest at Station SW-132. Generally, all analyte groups (radionuclides, volatile organic compounds, and metals) for Station SW-59 exhibit concentrations exceeding ARARs at a frequency of greater than 10 percent. Also, mean concentrations significantly exceed ARARs, particularly for the VOCs. Station SW-61 does not exhibit radionuclide contamination in excess of ARARs, but volatile organic compounds (tetrachloroethene, trichloroethene, chloroform and vinyl chloride) were observed to exceed ARARs, as well as some metals (aluminum, zinc, and dissolved manganese). However, as shown in Table 5-1, ARAR exceedances for the VOCs at SW-61 are low in

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Table 5-1

**Summary of Surface Water Analytes That
Exhibit ARAR Exceedance at a Frequency > 10%**

Station SW-59 (ARAR/MEAN) ^a	Station SW-61 (ARAR/MEAN) ^a	Station SW-132 (ARAR/MEAN) ^a
Americium-241 (0.05/0.0246)		
Gross β (19.00/6.7979)		
Total Uranium (10/5.9681)		
1,1 Dichloroethene (7/5.86)		
Carbon Tetrachloride (5/122.04)	Carbon Tetrachloride (5/5.48)	
Chloroform (1/21.84)	Chloroform ^b (1/2.28)	Chloroform ^c (1/2.50)
Tetrachloroethene (1/73.60)	Tetrachloroethene (1/4.52)	Tetrachloroethene ^c (1/2.50)
Trichloroethene (5/85.20)	Trichloroethene (5/5.42)	
Vinyl Chloride ^b (2/5.16)	Vinyl Chloride ^b (2/6.16)	Vinyl Chloride ^c (2/4.77)
Aluminum (200/827.99)		Aluminum (200/129.85)
Iron (1,000/664.26)		
Lead (5/2.45)		Lead (5/2.32)
Mercury (0.20/0.13)		Mercury (0.20/0.12)
Zinc (50/255.00)	Zinc (50/123.94)	Zinc (50/31.65)
	Dissolved Manganese (50/63.67)	Dissolved Manganese (50/40.72)

^a Radionuclide ARAR/MEAN values are in pCi/l. Metal and VOC ARAR/MEAN values are in $\mu\text{g/l}$.

^b Estimated values below Contract Required Detection Limits (CRDLs) cause > 10% frequency of ARAR exceedance for this analyte.

^c Although this analyte was not detected in any samples above the CRDL, it is not possible to determine the frequency of ARAR exceedance because the CRDL exceeds the ARAR.

magnitude with the mean concentrations near ARARs. Station SW-132 does not exhibit radionuclide contamination in excess of ARARs, and may or may not exceed ARARs for specific volatile organic compounds (chloroform, tetrachloroethene, and vinyl chloride). ARARs for 1,1-dichloroethene, carbon tetrachloride, and trichloroethene were not exceeded at SW-132. The uncertainty associated with chloroform, tetrachloroethene, and vinyl chloride at SW-132 relates to the fact that ARARs for these compounds are set at levels below the method detection limits. Nonetheless, ARAR exceedances for VOCs at Station SW-132 are below the method detection limits, indicating relatively low contamination levels. Regardless of the uncertainties associated with volatile organic compounds, it is clear that contamination levels at SW-61 and SW-132 are low and continued collection and treatment of these flows may not be necessary to achieve the objectives for OU2 surface water management.

5.2 EVALUATION OF PUBLIC HEALTH RISKS

A risk assessment has been performed to evaluate potential public health risks from exposure to surface waters at SW-59, SW-61, and SW-132 (Appendix B). The risks associated with exposure to each of the three sources (untreated) as well as that associated with exposure to different combinations of the sources (untreated) were evaluated. The potential risks were analyzed under two scenarios: direct consumption of water from the sources and consumption of water from Pond B-5, which is further downgradient.

Potential contaminants for the OU2 surface water locations were selected through statistical comparison of the sampling data from these locations with the results from sampling of background surface waters (Appendix A). As a result of these comparisons, the compounds listed in Table 4-2 were identified as the potential contaminants to be evaluated for this assessment. Because there was no attempt to eliminate potential contaminants based on toxicity, this provided an additional level of conservancy to the assessment. For the purposes of the assessment, the concentrations for total metals and total radionuclides were used in the calculations of carcinogenic and noncarcinogenic risks.

The Lifetime Excess Cancer Risk (LECR-I) representing cancer Incidence resulting from chemical exposure, the Lifetime Excess Cancer Risk for Mortality (LECR-M) resulting from radiological exposure, and noncarcinogenic Hazard Index (HI) were all estimated in accordance with EPA guidelines. Computations of radiological dose to assess compliance with DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, were performed following DOE guidance.

The first scenario (Scenario 1) assessed was a residential setting in which long-term exposure occurs as a result of using OU2 surface water as a domestic water supply. The exposure pathway examined was direct ingestion of the surface water from each station (SW-59, SW-61, and SW-132) or a mixture of surface water from various combinations of flow from these stations. This scenario is conservative because the likelihood of a residence being constructed on OU2 is quite low. Currently, there is no actual exposure to the surface water. Another scenario, somewhat less conservative than that described above, was to assume direct consumption of water from Pond B-5¹ after contamination by various combinations of flow from the OU2 sources. In this scenario (Scenario 2), it is assumed that the contaminant load to Pond B-5 is entirely from the OU2 sources, but the flow into B-5 includes other (presumed uncontaminated) sources, e.g., sewage treatment plant discharges, runoff, etc.

For each scenario, in order to examine and apportion the risk from the different OU2 surface water sources, risk estimates required calculation based on the proportion of flow contributed by each source to the total flow considered under different conditions. The conditions examined were:

- 1) SW-59 not collected, SW-61 and SW-132 collected and treated. Total risk is attributable to SW-59.
- 2) SW-61 not collected, SW-59 and SW-132 collected and treated. Total risk is attributable to SW-61.

¹ Pond B-5 was selected as the receiving water body because it is the pond where discharges from the sources eventually accumulate. Discharges from this pond are routed through Pond A-4 and ultimately off site.

- 3) SW-132 not collected, SW-59 and SW-61 collected and treated. Total risk is attributable to SW-132.
- 4) SW-59 and SW-61 not collected, SW-132 collected and treated. Total risk is attributable to SW-59 and SW-61.
- 5) SW-61 and SW-132 not collected, SW-59 collected and treated. Total risk is attributable to SW-61 and SW-132.
- 6) SW-59, SW-61, and SW-132 not collected. Total risk is attributable to all of the sources.
- 7) SW-59 and SW-132 not collected, SW-61 collected and treated. Total risk is attributable to SW-59 and SW-132.

Conditions 1 through 3 allowed the examination and comparison of the risks associated with each individual source examined. The other conditions, 4 through 7, allowed the examination of the risks associated with different combinations of treatment and discharge from the sources.

Results of the nonradionuclide risk assessment for Scenario 1 are presented in Table 5-2, which provides both the LECR-I and HI for each condition examined. As can be seen in the table, LECR-I values fall within the range (10^{-4} to 10^{-6}) for Superfund site remediation goals with the exception of Conditions 1 and 7 (which just exceed 10^{-4}). Two values for HI (Conditions 1 and 7) exceed the Superfund noncancer HI goal of 1.0.

The highest LECR-I and HI values are associated with Condition 1, which represents exposure to untreated surface water at SW-59, the source with the highest contaminant concentrations. It is also apparent in Table 5-2 that exposure to untreated surface water at SW-59 in any combination with the other source waters either drives the associated HI above the EPA goal of 1.0 or causes the value of HI to approach the 1.0 limit.

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Table 5-2

Nonradiological Risk and Hazard Index Summary for
Scenario 1

Condition	SW Sources Not Treated	Lifetime Excess Cancer Risk-Incidence				Hazard Index			
		Total	Fraction ^a			Total	Fraction ^a		
			59	61	132		59	61	132
1	59	4.0E-4	1.0	— ^b	—	6.7	1.0	—	—
2	61	5.8E-5	—	1.0	—	0.4	—	1.0	—
3	132	9.6E-5	—	—	1.0	0.1	—	—	1.0
4	59,61	8.2E-5	0.34	0.66	—	0.8	0.56	0.43	—
5	61,132	6.8E-5	—	0.64	0.36	0.3	—	0.89	0.11
6	All	8.5E-5	0.24	0.48	0.28	0.6	0.52	0.42	0.05
7	59,132	1.5E-4	0.46	—	0.54	1.3	0.92	—	0.09

^a Fraction contributed by each source to condition-specific LECR-I or HI.

^b A dash (—) denotes that the source was not included in, and not assessed for, that particular condition.

Note: EPA considers an LECR-I greater than 10^{-4} and an HI greater than 1.0 as indicative of a condition for possible remedial action.

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The results for Condition 7, exposure to untreated SW-59 and SW-132 surface water, are elevated due to insufficient volume from SW-132 (5 gpm) to dilute the discharge from the most contaminated source, SW-59. The LECR-I value (1.5×10^{-4}) and the HI value (1.3) are in excess of the EPA criteria and are, thus, unacceptable.

The lowest LECR-I and HI values for any combination of two or more sources are those for Condition 5, which represents treatment of SW-59 and exposure to untreated water from SW-61 and SW-132. For this combination of sources, an LECR-I of 6.8×10^{-5} and an HI of 0.3 were calculated, both of which are within the EPA Superfund remediation guidelines discussed above. Therefore, based on potential public health risks, the continued collection and treatment of these waters is unwarranted. It is further noted that Condition 6 represents exposure to the mixture of untreated surface water from all of the OU2 sources and, thus, is equivalent to a baseline or no-action condition. The LECR-I (8.5×10^{-5}) and HI (0.6) values calculated for this condition are also below the EPA criteria.

The results of the nonradiological risk assessment for Scenario 2 (refer to Appendix B) indicate all of the associated LECR-I values are within the EPA remediation goals of 10^{-4} to 10^{-6} with the highest value, 6.7×10^{-6} , for Condition 2. In addition, all HI values are at least one order of magnitude below the EPA acceptable level of 1.0; the highest value of 0.05 was for Conditions 1 and 4 and is associated with the contaminant levels discharged from SW-59. Thus, for this scenario there are no unacceptable risks presented by the OU2 surface water sources.

The results of the radionuclide risk assessment indicate that LECR-M values are well within the Superfund site remediation goals of 10^{-4} to 10^{-6} (refer to Appendix B). Thus, the risks associated with radionuclides discharging from the OU2 sources are not the primary factors for determining the need for collection and treatment of the sources.

The radiological dose analysis to demonstrate compliance with DOE Order 5400.5 shows that potential radiological doses related to exposure resulting from consumption of surface water from

the OU2 sources would be more than an order of magnitude below the DOE compliance guideline of 100 mrem/year for Scenario 1 and more than two orders of magnitude below the guideline for Scenario 2 (refer to Appendix B).

5.3 OTHER CONSIDERATIONS

Other risk factors that need to be considered in future remedial planning for OU2 surface water include waste generation and management. As indicated in previous discussions, wastes generated by the FTU are currently managed as low-level mixed waste. With the combined flows of SW-59, SW-61, and SW-132, substantial waste volume (26,000 pounds of sludge, 6,000 pounds of spent GAC) has accumulated and will continue to accumulate to the point where long-term management will become problematic. Risks are also posed by the transportation and disposal of these wastes. Additionally, emissions of particulate, nitrogen and sulfur oxides, VOCs and carbon monoxide from the diesel-fired generator (refer to Section 4.5.3) may be potentially significant (33.5 pounds of particulate; 31 pounds of sulfur oxide; 469 pounds of nitrogen oxides; 32 pounds of VOCs; and 102 pounds of carbon monoxide per 1,000 gallons diesel fuel consumed).

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

6.1.1 FTU Effectiveness

The FTU was generally effective in reducing influent analyte concentrations. Influent analyte concentrations were often below ARARs. Even though these concentrations were low, comparison to effluent analyte concentrations showed a small but measurable net reduction in concentration. Influent concentrations were generally too low to evaluate the system's effectiveness in treating higher contaminant levels. When analyte concentrations were above ARARs, the system lowered the concentrations to below ARARs with only rare occasions of an effluent analyte concentration above ARAR.

Contaminant losses occurred upstream of those units designed to treat specific analyte groups. Some loss of metals and radionuclides occurred in collection, transport, and equalization of the influent surface water. A significant loss of VOCs occurred in collection, transport, equalization, and mixing of the surface water in the reaction tanks of the RRS.

6.1.2 Future Surface Water Management

The surface water characterization indicates that while the seep at SW-59 contains analytes in concentrations that exceed ARARs with significant frequency and magnitude, the surface waters at SW-61 and SW-132 exhibit limited contamination. The risk associated with direct ingestion of the untreated surface water sources at SW-61 and SW-132 is well below the EPA site remediation goals (the risk associated with exposure to all three sources is also below EPA site remediation goals). There is limited risk reduction afforded by the continued collection and treatment of SW-61 and SW-132, and the costs associated with the treatment of these sources is exorbitant. The cost of treatment (excluding residuals management) of all three sources

during Phase II was approximately \$29,000/pound of total metals removed, \$2,700,000/pound of total radionuclides removed, and \$557,000/pound of total VOCs removed. It is likely that a significant portion of the mass of metals and uranium (uranium represents >99% of the radionuclides removed) that is removed by the treatment system is of natural origin.

Residuals generation and management costs further offset any benefits realized by the operation of the FTU. Residuals include not only sludge and spent GAC, but also air emissions from the diesel generator, solid waste in the form of used air and oil filters from the generator, and contaminated PPE used in sampling and maintenance activities. The amount of sludge produced per unit mass of contaminant removed averages as follows: approximately 352 pounds of sludge/pound metals, 32,099 pounds sludge/pound radionuclides, and 1,579 pounds of spent GAC/pound VOCs. The costs associated with treatment and disposal of these wastes have not yet been assessed but are significant (estimated at \$130,000 for current inventory). These wastes are currently being stored in RFP interim storage areas, pending availability of a permanent TSD facility.

6.2 RECOMMENDATIONS

Considering the minimal contamination present in SW-61 and SW-132, the collection and treatment of these sources is not necessary to achieve the OU2 IM/IRA objectives. Given the minimal public health risks associated with ingestion of untreated water from these sources, the low frequency and magnitude of ARAR exceedances, the high cost of treatment, and the costs and risks of secondary waste generation and management, it is recommended that collection and treatment of SW-61 and SW-132 be discontinued.

Collection and treatment of SW-59 provides minimal risk reduction to human health. The public health risks associated with exposure to this water in combination with the other two sources is below EPA site remediation goals. VOCs at this source represent the contaminant class posing the greatest public health risks. However, significant VOC losses to the atmosphere occur in the FTU prior to treatment by GAC. Such losses are occurring naturally without treatment. In

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light of this observation, the continued operation of the IM/IRA should be re-evaluated. If the IM/IRA is discontinued, the treatment system could still be used to treat groundwater or surface water from other OUs. For example, the system is currently intended for use in treating groundwater for the OU2 Subsurface IM/IRA.

SECTION 7

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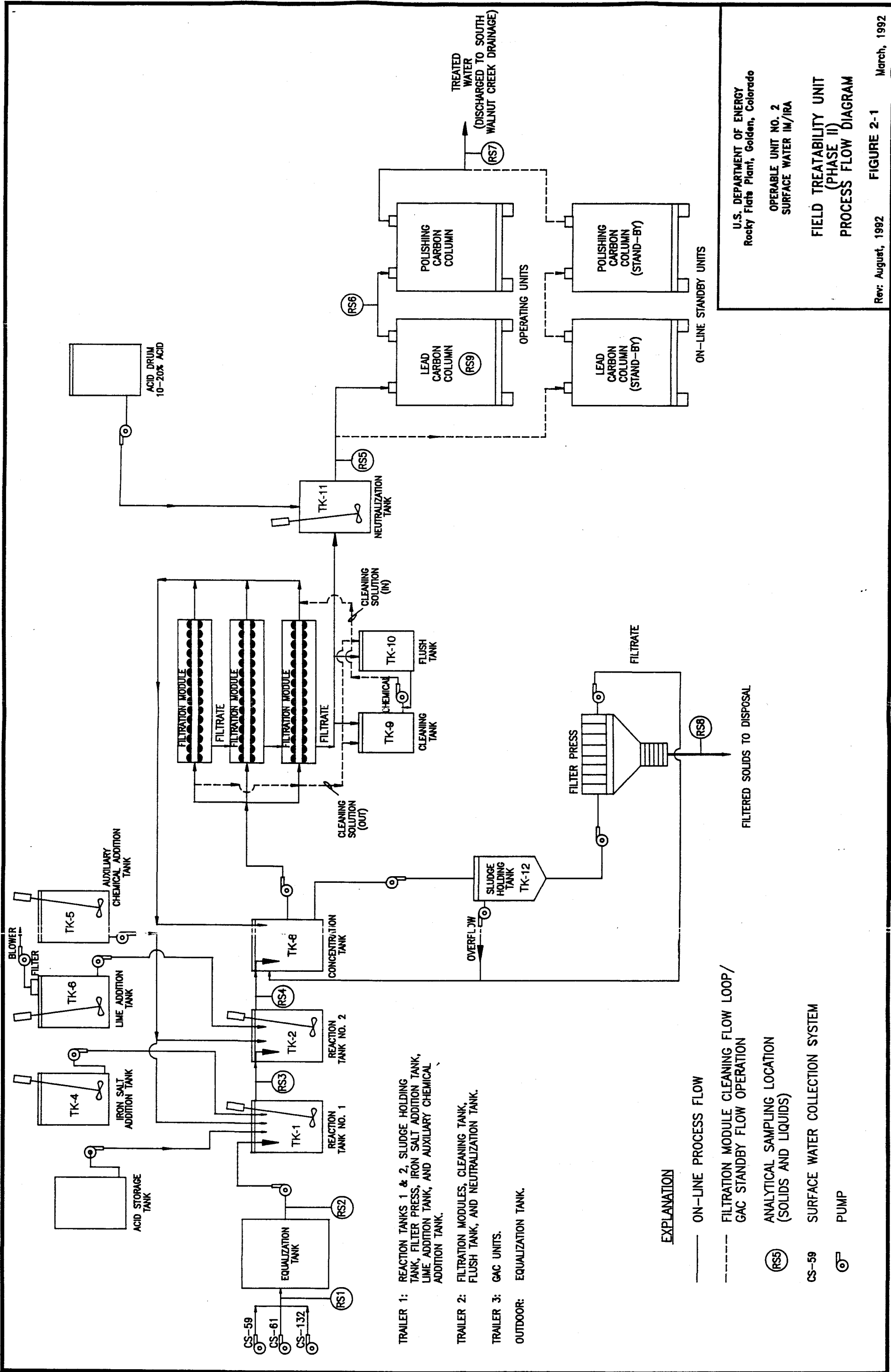
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TRAILER 1: REACTION TANKS 1 & 2, SLUDGE HOLDING TANK, FILTER PRESS, IRON SALT ADDITION TANK, LIME ADDITION TANK, AND AUXILIARY CHEMICAL ADDITION TANK.

TRAILER 2: FILTRATION MODULES, CLEANING TANK, FLUSH TANK, AND NEUTRALIZATION TANK.

TRAILER 3: GAC UNITS.

OUTDOOR: EQUALIZATION TANK.

EXPLANATION

- ON-LINE PROCESS FLOW
- FILTRATION MODULE CLEANING FLOW LOOP/ GAC STANDBY FLOW OPERATION
- ANALYTICAL SAMPLING LOCATION (SOLIDS AND LIQUIDS)
- SURFACE WATER COLLECTION SYSTEM
- PUMP

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
SURFACE WATER IM/IRA

FIELD TREATABILITY UNIT
(PHASE II)

PROCESS FLOW DIAGRAM